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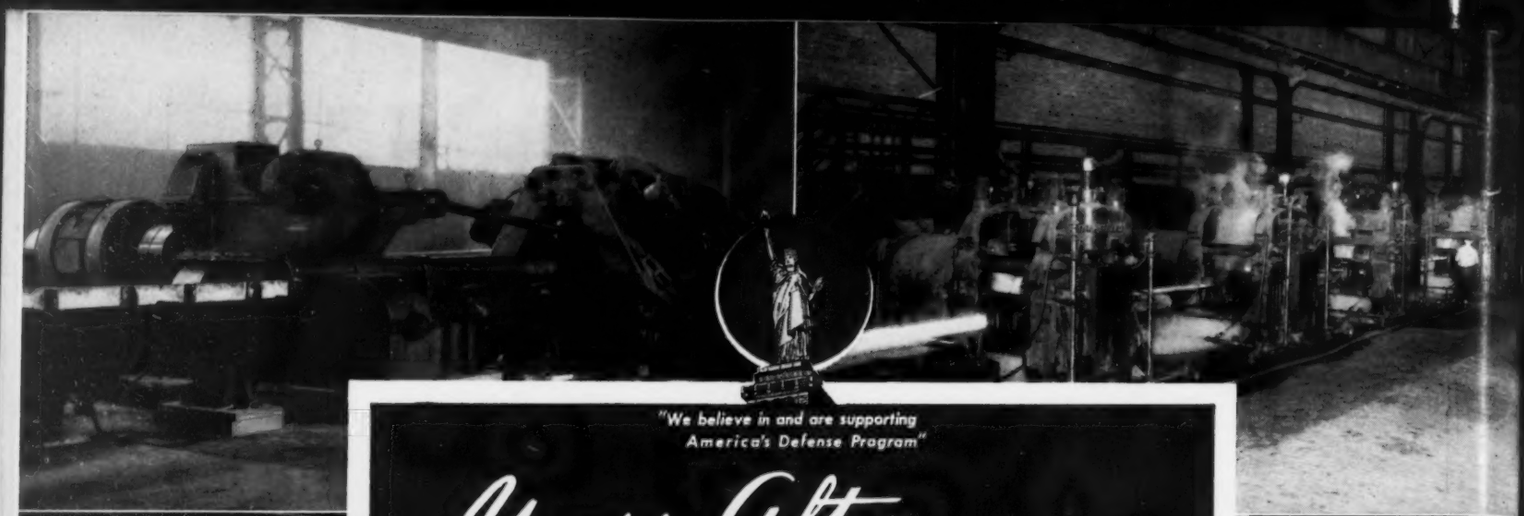

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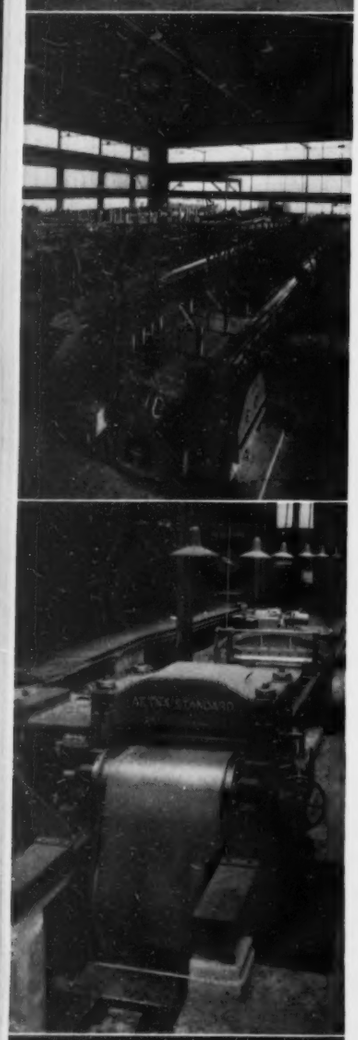

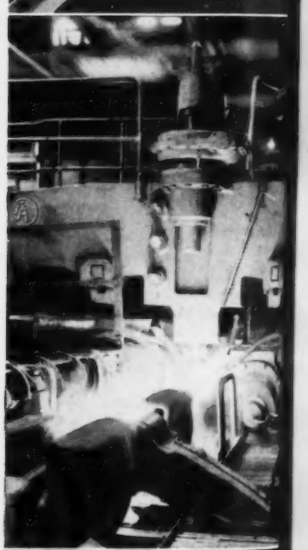

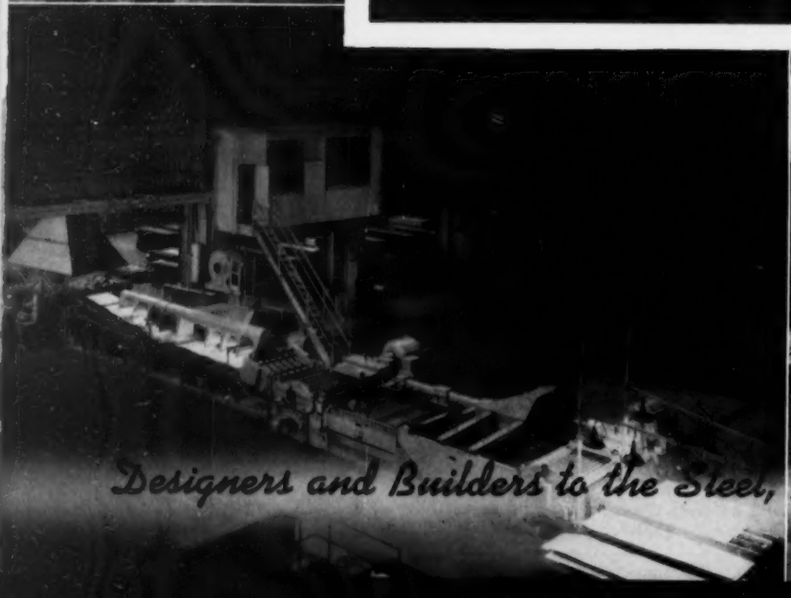

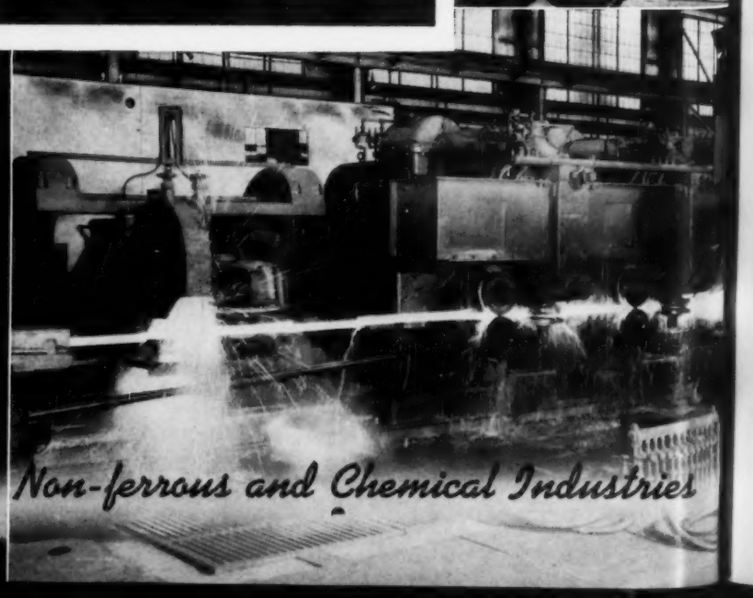

Designers and Builders to the Steel, Non-ferrous and Chemical Industries

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ALCOA

1

WE INTERRUPT our regular messages to report what's what with aluminum.

AT THE MOMENT delivery for civilian use must make way for defense. Everybody knows the reason. Defense requires and is using more aluminum per month than peacetime America ever consumed.

NEVERTHELESS, we intend that no one shall have to forego the things aluminum can do best one minute longer than we can help.

THERE IS NO SHORTAGE of bauxite, nor of anything else, except time. And Father Time is being given the race of his life.

WE ARE MOVING, for example, 35,000 yards of earth a day at Alcoa, Tenn., to get 50 acres under a single roof by September. It will require 193 carloads of roofing felt. Some of the operations in that plant will start even before the walls are up. That's an annual rolling capacity for 120 million pounds of high strength alloy sheet coming along fast.

LAST MARCH WE STUCK the first shovel in a cow pasture near Vancouver, Wash. In September a 30 million pound plant was delivering metal. It has been doubled, already. A third 30 million pound unit starts delivering in April; a fourth in May; a fifth in June. From cow pasture to 150 million pounds annual capacity in 15 months.

A SIDELIGHT: To make that 150 million pounds of aluminum, we first have to build factories to make 120 million pounds of carbon electrodes. We have to obtain the equipment (transformers, rectifiers, and the like) to feed 162,500 kw. of electricity into the reduction furnaces. This is a generating capacity equal to that of the state of Delaware plus twice that of Mississippi.

WHAT OF TOTAL PRODUCTION? In addition to Vancouver, further installations are being made at other of our plants, so that in less than a year their total capacity will be more than double that of 1939, when 327 million pounds were produced.

IN THE VERY MIDST of this demand we have lowered the price of aluminum ingot 15%. We state, without reservation, our hope that the price can be still further reduced.

DEFENSE APPLICATIONS use aluminum for exactly the same reasons you do. Defense priorities on aluminum simply say that there are some fundamental things that aluminum does supremely well. It will do them still better as important lessons in production, fabrication, and application are learned from every additional pound being produced and used.

YOU, SIR, have been using aluminum conductors and bus bars. It is not easy nor convenient to have to substitute other materials temporarily. We want you to know that we intend to make this hardship as short-lived as possible. Your aluminum is on the way. It is a promise.

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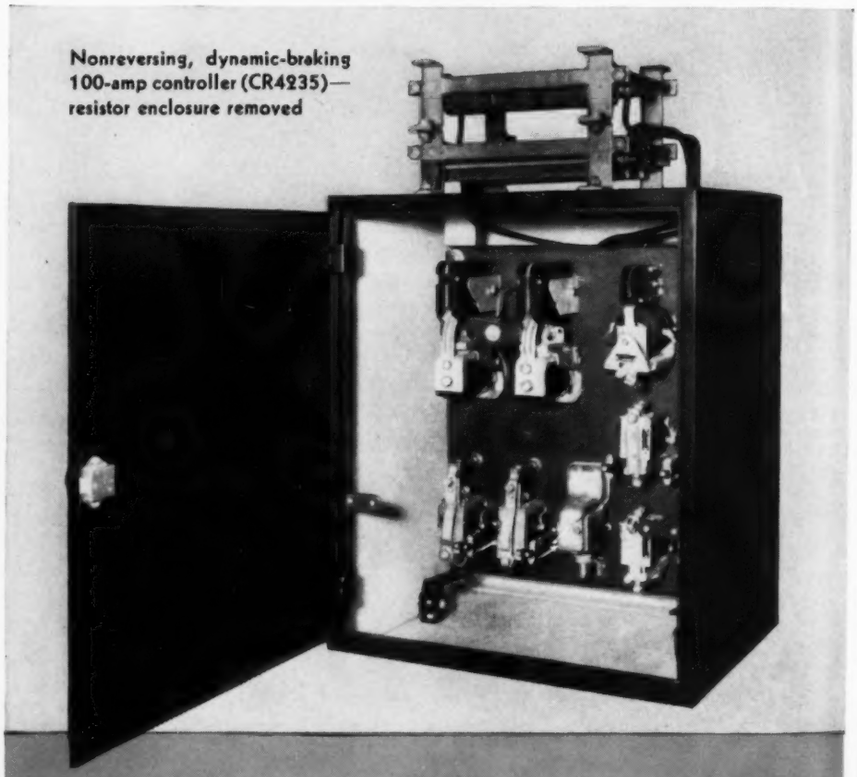

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JUST three of their features—swinging panel, nonbreakable resistor mounted on top of the cabinet, and steel-mill-duty contactors—make these starters an asset to any steel mill.

Here's a complete line of starters for reversing or nonreversing service; for controlling constant-speed and adjustable-speed motors; with or without dynamic braking; with magnetic time-limit acceleration; and with inverse-time and instantaneous overload protection.

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Safety, accuracy, and dependability, coupled with the ability to take rough treatment, make it just the thing for protecting and controlling the motors that drive your steel-mill accessories. Pumps, fans, and machine tools are common applications.

Get in touch with your General Electric representative today and have him explain all the outstanding features of this improved line of starters. General Electric, Schenectady, N. Y.

1. Swinging Panel
This feature means that it will be easy to get to the back of the panel to make connections, and to check the wiring. By loosening only two thumbscrews, you can swing the panel forward with almost no effort.

2. Nonbreakable Resistor on Top of Cabinet
This design allows for better dissipation of heat. Amply protected by a ventilated, steel enclosure, this resistor, like the rest of the starter, is designed for heavy duty and is suitable for jogging service. Its NEMA classification is No. 135.

3. Steel-mill-duty Contactors
The heavy-duty, all-steel contactors are the same as used on your other vital mill auxiliaries. Made especially for the heavy duty required in steel mills, their life is exceedingly long.

Effects of SOAKING PIT OPERATION Upon Steel Conditioning

By C. L. Labeka, Plant Metallurgist
PITTSBURGH STEEL COMPANY
MONESSEN, PENNA.

Presented before A. I. S. E. ANNUAL CONVENTION,
Chicago, Illinois, September 24-27, 1940

▲ IN any steel plant, the amount of surface conditioning on steel blooms or bars is directly related to the open hearth melting and deoxidation practice, the open hearth pit practice, and the soaking pit and rolling practice.

Some grades of steel which demand an exceptionally good surface, free from seams, laps and scabs must be given a very thorough conditioning. Other grades of steel in which surface requirements are not so rigid are given a lighter inspection and conditioning. This resolves itself into classifying the grades of steel made and applying the degree of chipping or scarfing to depend upon the surface requirements and cost.

In every case, however, it is advisable to attempt to control the factors which do affect the surface qualities so that a minimum amount of conditioning will be necessary.

In the open hearth we find that some factors such as the type of steel, whether rimmed, capped or killed, the analysis of the steel, surface blowholes, ingot cooling cracks, scabs and weak ingot skin have a decided influence upon subsequent surface defects on the rolled bars.

In the blooming mill, track time, capacity of the pits, time of soak and optimum rolling temperatures all have an effect upon steel surface.

During the past ten years there has been a great amount of development work done in the open hearth. With the advent of slag control, much has been learned about the chemical reactions which occur in the furnace. This has benefited the steel melter in enabling him to duplicate very closely heat after heat by better manipulation of the slag.

In the open hearth pit, improved mould preparation, better pouring practice, the use of big-end-up moulds, equipped with a hot-top, all have contributed to a better ingot practice.

It has only been lately that the same interest and control has been applied in the blooming mill. Formerly, the open hearth and blooming mills existed as two separate, distinct units, each one more or less criticizing the other. When a heat rolled very well, the open hearth operators were told that they had done a good job. However, when a heat cracked up pretty badly in the rolling mill, the open hearth melters and pit men were criticized for making a bad heat. It is true that some of the heats were not normal and bad rollings could be attributed to faulty open hearth practice; however, it is also true that the blooming mill was not right in every case. There were times when cold ingots were charged into hot pits, or in order to get the tonnage up on a certain turn, steel, which had not been given sufficient soaking, was rolled.

It was only by very thorough observation and patient work that certain fundamental conditions were found which proved without a question that standard practices had to be set up and followed. Just as in the open hearth, help had to be given the soaking pit heaters and blooming mill operators. When an abnormal heat is noticed in the open hearth today, one of the functions of the open hearth observers is to transmit all the information they can to the blooming mill. The blooming mill observers, the soaking pit heaters and the blooming mill operators must know the type of steel they are dealing with in order to better judge how the heating and rolling of the ingot should be properly made.

Since the open hearth and blooming mill are so closely related and the condition of the ingots as they are charged into the soaking pits does have a decided effect

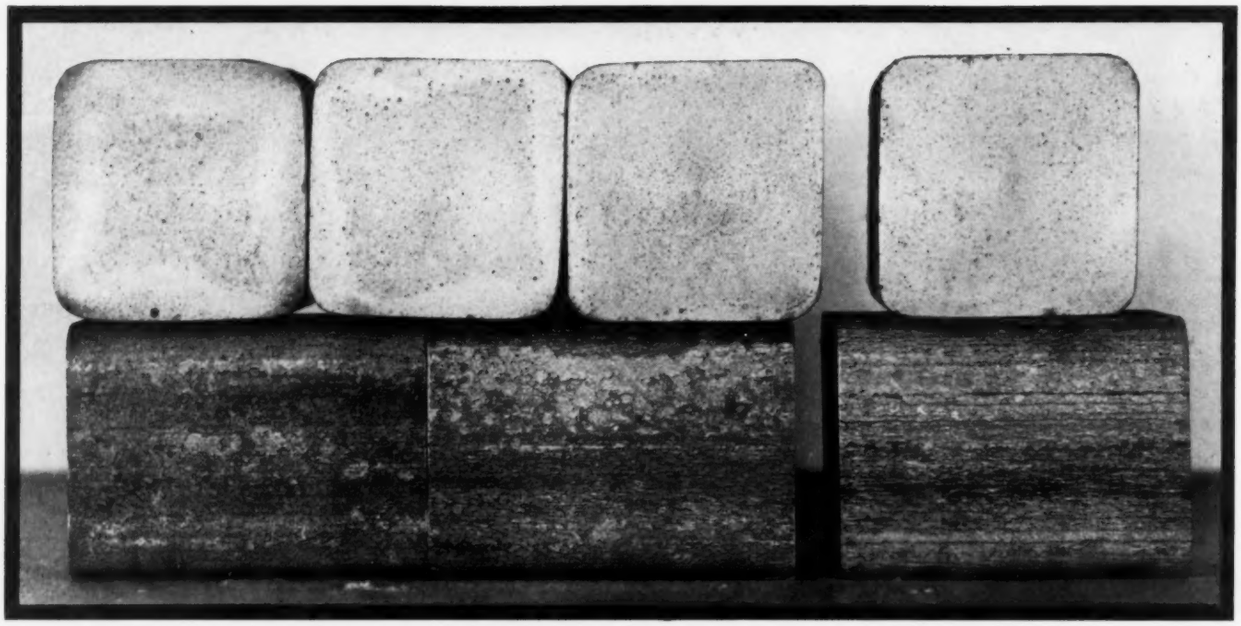


Figure 1—Variation in skin thickness is illustrated by these bar sections, ranging from practically no skin on the right to a heavy skin on the left.

upon subsequent defects in the rolled bloom or bar, let us first examine some of these conditions to see how they affect the surface characteristics. These factors are by no means all of the conditions which may affect the ingot, but they should point out that only under rigid control and very close cooperation with the open hearth can the blooming mill be expected to yield a satisfactory product.

EFFECT OF THIN SKINNED INGOTS

In the open hearth it has been possible to maintain the deoxidation of the heats within very close limits. This closer deoxidation practice, together with a better knowledge of temperature control and pouring practice, has enabled the open hearth operators to control rimming and capped steels so that within certain limits various thicknesses of skin can be produced.

A rimmed steel has a thick skin which yields a bar surface comparatively free from surface defects. The disadvantage of full rimmed steels, however, is the variation that exists in the top to bottom of the ingot as well as rim to core.

A capped steel is one in which the rimming action has been suppressed and the skin thickness has been lessened with a decreased variation from top to bottom of the ingot as well as rim to core.

Various skin thicknesses can be made, the limitations being dependent mainly upon the degree of oxidation of the heat and the analysis desired. Hence, if minimum segregation is desired, a minimum skin thickness for proper rolling is made.

Although it is possible to control the skin thickness to a certain extent, a steel in an analysis range of .15/.25 carbon–.40/.60 manganese will be relatively thin skinned. A lower carbon, higher manganese grade, such as .10/.15 carbon–.60/.90 manganese, and high sulphur grades also fall into this group.

Rimmed steels which rise considerably in the moulds have a thin skin on the butt portion of the ingot.

On killed grades, high pouring temperatures and ingots that boil on the top lead to a weak, thin ingot skin.

In the top photographs in Figure 1, various skin thicknesses are shown on capped and rimmed grades, from practically no skin on the bar on the right to a full rimmed steel on the extreme left. The analyses of the bars and a section of the etched surface of the bars after rolling are shown below.

In examining the surface of the bars shown, it is evident that the thicker skinned ingots with proper soaking pit and rolling practice will yield bars relatively free from surface seams. It is also very evident that the exceedingly thin skinned ingots are conducive to surface seams.

Examination of these ingots when stripped from the moulds, in most cases reveals a good surface so that this is not always a criterion for thin skin; however, it was found that this type could be identified during the pouring operation in the open hearth.

When a condition such as this is noticed on capped or rimmed grades, or if a thin skin has been obtained on killed grades because of abnormal practice, the open hearth observer can pass this information on to the soaking pits. The heater, by damping this type of steel more frequently and by very careful heating, can often save the ingots. It was found by this method that many heats could be rolled with good surface results

which otherwise would have resulted in high rejections in the rolled bars or necessitated excessive chipping.

It is far more economical for the open-hearth to admit that an abnormal heat has been made, since in many cases this knowledge can save a heat of steel.

EFFECT OF SURFACE BLOWHOLES

Surface blowholes are small cavities resulting from the trapping of evolved gases in the metal during solidification.

Figure 2 shows chips taken from the surface of two rimmed ingots. The one on the bottom shows a good clean surface but on the top, surface blowholes are seen.

This is an ingot defect which can lead to more serious results than thin skin. It was found that in the soaking pit operation, oxidation of the ingot surface causes sufficient scaling which exposes these blowholes to the pit gases. These oxidized blowholes will not weld upon rolling and short, choppy seams will inevitably result on the rolled bars.

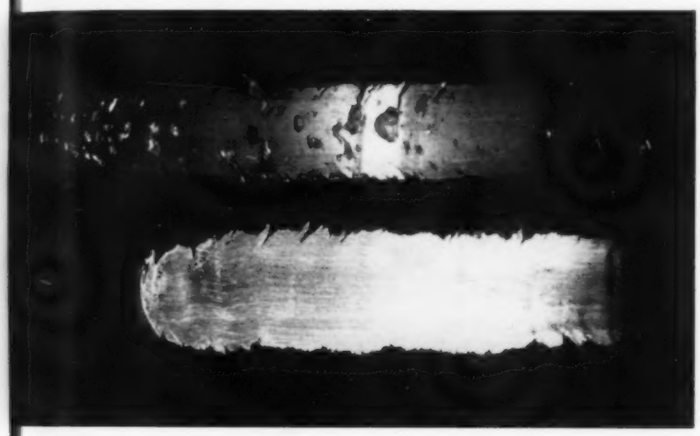


Figure 2—The chip at the top in this illustration shows evidence of surface blowholes, while that below shows a good clean surface.

This is a condition for which it would be very easy to lay the blame upon the soaking pit heater's shoulders. But rather than face the high conditioning costs and greater scrap losses it is far better for the open-hearth to prevent these surface blowholes with rigid control even at a slightly increased cost, and there is no question that this control will far compensate for the greater increase in chipping costs and scrap losses than if this control is not made available.

EFFECT OF DELIVERY TIME

Special care must be taken of delivery or track time. This time is generally taken from the time the heat is finished pouring to the time the heat is charged into the soaking pits.

Those plants which have the soaking pits located close to the stripping platforms have an ideal condition, since as soon as the ingots are stripped they can be charged hot into the soaking pits. Some plants have the soaking pits located quite a distance away from the stripper and there are times when the ingots can not be charged as hot as it is desired. In some cases the soaking pit capacity is limited and heats must lay out for hours before they can be charged.

Capped and rimmed ingots when stripped at the open hearth are exposed to the cooling effect of the atmosphere and if the delay before charging into the pits is appreciable, conditions arise which make it practically impossible to get good surface on the rolled bars even under good soaking pit operations.

In handling thin skinned, capped ingots, it was found that if the ingots, after stripping, were delayed in charging, fine hair-line horizontal cracks invariably resulted. These ruptures in most cases were superficial but it was found that at times, what appeared to be a superficial skin crack would extend as deeply as ½ in. In cold weather the rapid chilling effect of the thin skin accentuates these skin ruptures. These cracks become oxidized in the soaking pits and will not weld completely. This will, of course, lead to bloom cracks and many seams on the rolled bars. The best practice is to charge these thin skinned ingots as hot as possible into the soaking pits and it is not good practice to strip the ingots and bank this type of steel while hot since in cooling down to room temperature, cooling strains will be set up which cause these fine skin ruptures.

Where delays are inevitable, the soaking pits heaters should be notified of this ingot condition and, although they cannot "rescue" these ingots, they can, by careful heating, prevent these cracks from becoming larger due to a rapid thermal change to the ingot skin.

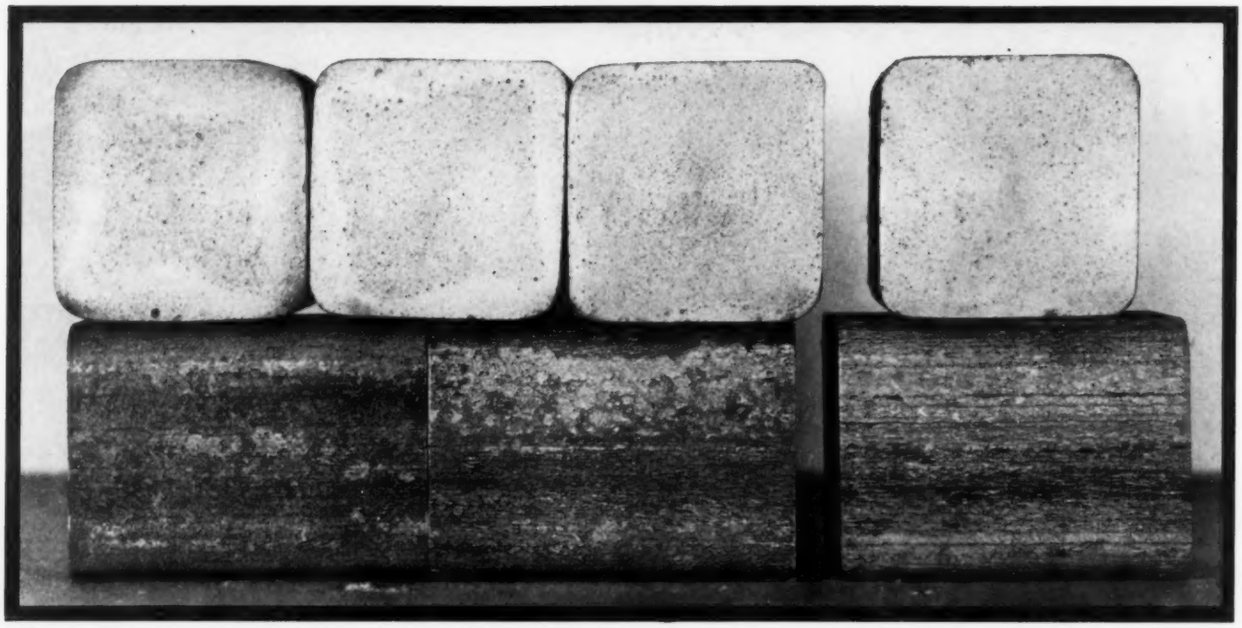
The thicker skinned, capped and rimmed ingots do not show this skin cracking as readily as the thin skinned grades. It was also found that this type could be heated faster in the soaking pits with no serious damage to the ingot surface.

It is worthwhile in a plant that makes both rimmed and capped grades, to "circle" rimmed heats and deliver first to the soaking pits the thinner skinned heats. In this manner, skin cracking, caused by cooling strains as a result of delays, can be kept to a minimum.

Killed grades, in most cases, are poured into big-end-up, hot-topped moulds. Since these ingots are delivered to the soaking pits in the moulds, the ingots cool more slowly than ingots which are stripped at the open-hearth slowly than ingots which are stripped at the open hearth. This slower cooling is a help in preventing skin cracks and generally the ingot surface is not damaged even though delivery of the heat is delayed. The only serious condition which arises in this case, is that if these ingots are charged into a hot pit, serious damage is done to the ingot surface due to the rapid heating of the ingot skin.

When delays are caused by no soaking space being available, ingots are almost certain to be charged into hot pits which will augment any cracking which may occur.

It can readily be seen that slow track time and other delays in charging the ingots into the soaking pits can lead to very poor surface quality, and it is only by a



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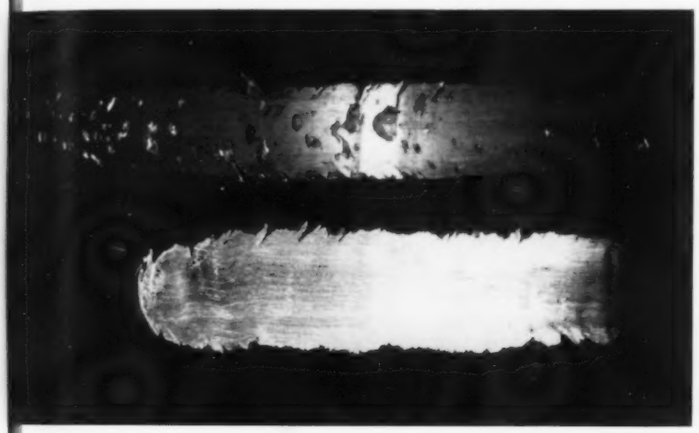

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In handling thin skinned, capped ingots, it was found that if the ingots, after stripping, were delayed in charging, fine hair-line horizontal cracks invariably resulted. These ruptures in most cases were superficial but it was found that at times, what appeared to be a superficial skin crack would extend as deeply as ½ in. In cold weather the rapid chilling effect of the thin skin accentuates these skin ruptures. These cracks become oxidized in the soaking pits and will not weld completely. This will, of course, lead to bloom cracks and many seams on the rolled bars. The best practice is to charge these thin skinned ingots as hot as possible into the soaking pits and it is not good practice to strip the ingots and bank this type of steel while hot since in cooling down to room temperature, cooling strains will be set up which cause these fine skin ruptures.

Where delays are inevitable, the soaking pits heaters should be notified of this ingot condition and, although they cannot "rescue" these ingots, they can, by careful heating, prevent these cracks from becoming larger due to a rapid thermal change to the ingot skin.

The thicker skinned, capped and rimmed ingots do not show this skin cracking as readily as the thin skinned grades. It was also found that this type could be heated faster in the soaking pits with no serious damage to the ingot surface.

It is worthwhile in a plant that makes both rimmed and capped grades, to "circle" rimmed heats and deliver first to the soaking pits the thinner skinned heats. In this manner, skin cracking, caused by cooling strains as a result of delays, can be kept to a minimum.

Killed grades, in most cases, are poured into big-end-up, hot-topped moulds. Since these ingots are delivered to the soaking pits in the moulds, the ingots cool more slowly than ingots which are stripped at the open-hearth slowly than ingots which are stripped at the open hearth. This slower cooling is a help in preventing skin cracks and generally the ingot surface is not damaged even though delivery of the heat is delayed. The only serious condition which arises in this case, is that if these ingots are charged into a hot pit, serious damage is done to the ingot surface due to the rapid heating of the ingot skin.

When delays are caused by no soaking space being available, ingots are almost certain to be charged into hot pits which will augment any cracking which may occur.

It can readily be seen that slow track time and other delays in charging the ingots into the soaking pits can lead to very poor surface quality, and it is only by a

synchronized plan between the open hearth and blooming mill that good results can be obtained.

In every case fast delivery to the soaking pits has proved that better surface and less conditioning will result.

EFFECT OF CHARGING COLD STEEL

When charging ingots that are colder than normal because of delays or when charging steel that is cold, such as banked ingots, the ingots should never be charged into a hot pit. Whereas in rapid cooling, strains are set up which yield skin ruptures, too drastic a change in temperature, which occurs when a cold ingot is placed into a hot pit, will also give skin cracks.

The pits should be cooled to within a few hundred degrees of the ingot temperature and then slowly brought up to temperature. This should especially be applied to thin skinned ingots and the higher carbon killed grades.

Figure 3 points out very clearly the degree of bloom cracks on .30/.40 carbon seamless grade ingots when charged into hot pits.

Along the horizontal line are shown the ingot color when charged into the pits. The various colors illustrate relatively the surface temperature, red being representative of approximately 1400 degrees F., dark red being about 1100 degrees F., near black showing just a slight color in the center portion of the ingots and black illustrating ingots that were cold.

The vertical line shows a cracking index, one representing ingots from heats which showed practically no cracks in the blooms during rolling, and six representing the majority of the ingots showing medium or heavy horizontal cracks in the ingots. These values are purely relative. The ingots were big-end-up 22 in. x 24 in., 8400 lb., and were rolled to 7½ in. x 7½ in. in eleven passes on a three high mill. It can be seen that bloom cracking was accentuated when black ingots were charged into hot pits.

This horizontal cracking was not seen in the ingot before charging but in a few cases could be seen under the scale just before the ingot entered the blooming mill. Rolling the ingot opened these cracks and considerable chipping had to be done on the bars.

In cases where the ingots are delivered to the soaking pits much colder than normal, the observer should caution the heater who can then cool the pits and carry on the heating of the ingots very slowly. It was found that when this practice was followed even high carbon steel above .50 carbon could be charged cold with normal surface results upon rolling.

The delay in the blooming mill soaking pits caused by cooling the pits before cold ingots are charged is by far compensated for by better surface, less conditioning and better yields in the finishing mills.

EFFECT OF STAMPING PIT OPERATION

The steel ingot, susceptible to many of the defects mentioned, is now charged into the soaking pits. In the pits a good heat can be ruined and an abnormal heat at times can be saved. All this can happen in one department upon which a great deal depends since conditioning costs and the behavior of the semi-finished bars in the finishing mill operations are affected by the methods of heating.

Here in the soaking pits, the unevenness of temperature of the ingots must be removed and the temperature brought up to a predetermined level. At this temperature the ingots are to be well soaked and then withdrawn and rolled.

Approximately ten hours were spent in making the heat of steel. An additional hour was used to pour the heat and another hour for stripping and delivery brings

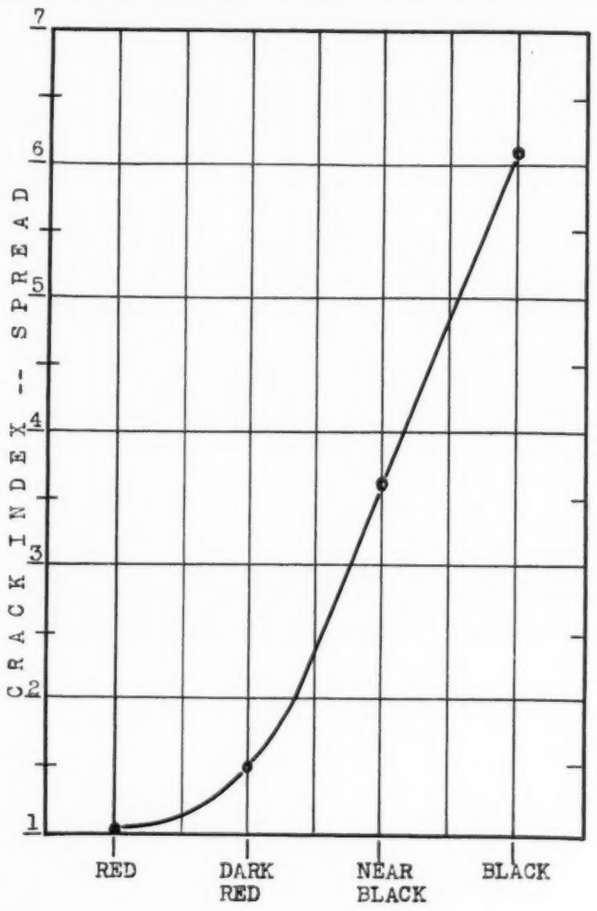


Figure 3—Curve showing relation between ingot temperature and degree of cracking of ingots charged into hot pits.

the time to about twelve hours. In addition, many hours were used to prepare the materials to be used in the open-hearth. Now we come to a department where if proper control is not practiced all this previous work can be practically wasted in the short span of two to six hours. Surely there can be no question that too much care, effort and control cannot be practiced in the soaking pit operation.

Some of the conditions to be particularly observed have already been mentioned. Many of these conditions

are not within the control of the soaking pit operators since serious damage to the ingot surface may have been done before delivery. Let us look at some conditions, however, which are within their control and should very rigidly be practiced.

The coke bed should be of a constant depth so that the ingots may remain upright in the pits. This is essential on lower carbon grades since the ingots have not entirely solidified if fast delivery has been made and the extent or position of the pipe may be changed. In all cases, however, the ingots should be upright and away from the walls since they will have a better chance to heat because more surface is exposed to the pit atmosphere. They should also not be placed in the center of the pit where direct impingement of the flame can cause damage to the ingot surface.

As previously mentioned, the pits should be at a temperature approximately that of the ingots to be charged in order to keep skin cracking down to a minimum.

Generally speaking, the time required to heat ingots in the soaking pits depends to a great extent upon the temperature of the ingots when delivered. When hot steel is delivered, the pits need not be cooled too low in temperature and the heating can be fairly rapid. When cold steel is delivered, the pits must be cooled down and the heating carried on more slowly. Thin skinned, high carbon and alloy ingots cannot be heated as rapidly as rimmed or lower carbon ingots if normal surface requirements are expected on the blooms or bars.

Abnormal heating conditions can range from cold or unevenly heated ingots which will not roll satisfactorily to ingots that have been burned, which in most cases necessitates scrapping of the steel.

Some of the common heating defects encountered in the soaking pits are "port marked" ingots, "burnt" ingots, "washed" ingots and uneven temperature.

"Port marked" ingots are very hot on the side nearest the flame. This heating condition, if prolonged, can lead to "washed" ingots or "burnt" ingots.

A "washed" ingot condition is caused by very high temperatures melting the oxide coating and this is not particularly detrimental on low carbon grades provided the ingot surface is uniform in temperature. On high carbon grades, however, there is danger of burning the ingot if the temperature is high enough to cause a "washed" surface.

Uneven temperature in an ingot can lead to bad surface results. In the rolling operation the temperature has a great influence upon the plastic flow of the metal and it is very evident that an uneven temperature will cause an uneven rate of metal flow. If rather heavy reductions are taken such as is common in three high blooming mill operation, this uneven rate of flow will cause tears in the ingot. This type of a heating condition is not always the fault of the heater.

In two-way fired soaking pits using producer gas as a fuel it is a difficult task for the heater, who generally has two or three blocks of pits to heat, to maintain a uniform temperature. Fluctuations in the producer gas analysis are often a sufficient detriment in controlling an even temperature.

If the pits are not deep enough to allow uniform heating for the entire length of the ingot, cracking may result when the ingot is being rolled. It has been proved that butt cracks on big-end-up ingots which are charged hot-top down may result if the pit is not deep enough to thoroughly heat the entire length of the ingot.

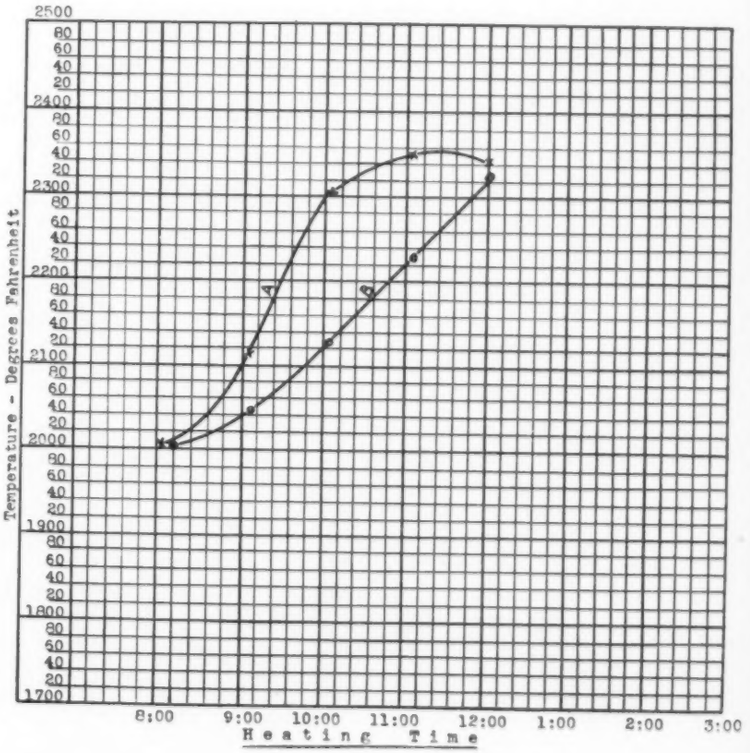
When the pits are overloaded it is difficult to thoroughly heat the ingots in the center of the pit. Common sense tells us that if a pit is designed to heat five ingots in a given time that seven ingots placed in that pit will not be uniformly heated in the same time. This condition, when capacity is limited, cannot be helped, but it is certain that unless a few of the ingots after being heated for a few hours are transferred to another hot, empty pit and are then uniformly heated, the uneven temperature in the ingots will cause cracks when being rolled.

Only when such conditions as proper soaking pit capacity and proper pit design are available can the heater do a satisfactory job. Here the observer with his optical pyrometer can be a great help. The heater is guided by these temperatures and has a better control over the pits. Heating curves with definite time-temperature cycles give assurance that the ingots will be uniformly heated to the proper temperature.

In Figure 4 two heating curves are shown representing two pits. These curves are not representative of any definite steel analysis but they do bring out the difference in heating cycles. The pits were two-way fired, all hand controlled. Curve A represents a good heating cycle since it can be seen that the ingots in this particular pit will be soaked between 2300 and 2350 degrees F. for two hours. Curve B shows a pit brought up gradually to 2325 degrees F., but in this case a minimum soaking will be obtained. The ingots from pit A would be uniform in temperature and when rolled would, without a question, yield better surface results than the ingots from pit B.

Surface temperatures taken while rolling the ingots

Figure 4—A heating cycle as indicated by curve A yields better results than a cycle of the type of curve B.



can be misleading since it is possible that ingots from both pits could have relatively the same surface temperature but the observers report would probably show bloom cracks and excessive seams in the finished bars on steel rolled from pit B. The ingots from this pit would not be uniformly soaked and ingots in the center of the pit would probably be at a lower temperature than those next to the gas ports. This would make it extremely difficult to maintain uniform rolling temperatures and it was observed that when straight line heating curves were obtained that cracking of the ingots resulted in practically every case when rolled on a three high mill.

Definite time-temperature ratios should be set up for various grades of steel. These values will also depend upon the amount of reductions taken and the rolling temperature desired. By soaking the ingots at a definite temperature for a given time assurance is given that all the ingots are thoroughly heated and the rolling temperatures should automatically fall in line.

It is well known that the type of soaking pits exerts a tremendous effect upon the uniformity of heating.

Recently the Pittsburgh Steel Company installed a block of one-way fired, automatically controlled pits. The block contains six pits, the capacity of each being 14—22 in. x 24 in., 8400 lb. ingots.

Each pit is 20 ft. 8 in. long, 6 ft. 5 in. wide and 12 ft. deep, 18 in. of which constitutes the coke bed. Natural gas is used as a fuel and the heating time for 14 cold ingots is 8 hr. The fuel consumption is 125 cu. ft. of natural gas or 138,000 Btu. per gross ton for hot steel and 1092 cu. ft. of natural gas or 1,208,000 Btu. per gross ton for cold steel. The automatic equipment consists of temperature control, fuel-ratio control, damper control, draft control and air-temperature control.

The covers are a two motor drive, lift and travel type with the full cover sealing in sand. The main advantage of this type is that when opening or closing the pits, it prevents damage to the cover brick and the top block from any foreign substance.

The recuperator consists of a carborundum tubular type having two banks of tubes terminating into a common collection chamber connected to the suction side of the double inlet alloy runner fan.

The control board for each pit contains a temperature indicating, recording controller; a push button control of the motor driven gas valve which manually determines the gas rate when not automatic, and an air-fuel ratio dial and setter for a six-way hydraulic valve which controls the air rate either manually or automatically with the gas rate. The control board for each pit also contains a pit damper, position indicator, an air-gas flow indicator and two valves which permit either automatic operation with the fuel rate or manual adjustment as when making bottoms.

On the master board there is an automatic air-temperature control; a stack draft control, setter and indicator; a gas manifold pressure control, setter and indicator and one group of gauges which indicate gas pressure, air pressure and flue pressure. It also contains push buttons to start and stop the air fan, an oil pressure indicator for the control system and push buttons for two oil pumps, one being a stand by.

Two features for this type of pit are that the gas is all burned in the pit, adding to the fuel economy, and there is no necessity making adjustment for any number of ingots charged.

It has been possible in these pits to obtain very close temperature control and the results obtained to date have shown that automatic equipment does present a control which has been impossible in the hand controlled two-way fired soaking pits.

Modern pit design has without a question contributed a great deal towards promoting better control and better quality at a lower operating cost.

EFFECT OF ROLLING TEMPERATURES

Some of the factors which affect rolling operation are the amount of draft, the analysis of the steel, the temperature and the speed of rolling.

The amount of draft on a two-high mill can be varied and on some grades light skin passes can be employed in order to break down the skin structure. On a three high mill, however, fixed drafts must be taken on all grades that are rolled.

The analysis of the steel affects the rolling operation since the power requirements and slippage at the roll faces vary with certain different grades.

The greater the speed of rolling the more superficial the work and the greater the increase in defects caused by tears in the ingots.

When an ingot enters the first pass in the blooming mill, the two sides in contact with the rolls are worked and compressed. This action breaks up the large crystal formation on these surfaces. The two sides of the ingot on the open sides of the rolls are not worked appreciably but are elongated along with the two sides in contact with the rolls. These large crystals are stretched considerably when heavy initial drafts are taken and ingot tears may result.

With the proper amount of work on all sides of the ingot, the surface metal will be rendered more plastic and malleable and will be strong enough to resist surface cracking when heavier passes are taken.

It was found that rolling temperatures play quite an important part. If the ingot is not heated to a sufficiently high temperature to render the metal plastic enough to flow uniformly, ingot tears will result on the sides opposite from the roll faces. Not only must the temperature be high enough but the ingots must be uniformly at that temperature, and unless the temperature throughout the ingot is well above the point for easy flow of the metal, a difference in temperature existing in an ingot will cause a non-uniform rate of metal flow which will lead to ingot cracks.

It is well known that all grades of steel cannot be rolled at the same temperature with satisfactory results. This rolling temperature, generally taken after the last pass in the blooming mill, depends primarily upon the grade of steel and the initial reductions taken. Some grades of steel can be hot worked more rapidly than others.

A study of the effect of rolling temperatures on the degree of bloom cracks indicated that minimum rolling temperatures had to be set up if good bloom surface was desired.

In Figure 5, two curves are shown which illustrate the difference that a 150 degree F. change in rolling

temperatures had upon the increased rate of bloom cracks. These values were obtained from plotting results of fifteen heats each of .10 carbon–.55 manganese, .35 carbon–.70 manganese and .60 carbon–.90 manganese plain carbon, killed grades. In every case, a standard ingot size of 22 in. x 24 in. cross section, weighing 8400 lb. was broken down to 7½ in. x 7½ in. blooms in eleven passes on a three high blooming mill.

Along the horizontal line we have the three different carbon steels. Along the vertical line we see the degree of bloom cracks illustrated by a cracking index spread of one to six. This shows the severity and increase in number of bloom cracks, the results being purely relative.

Curve A shows the relative values for the three grades of steel when rolled at a temperature of 1950 to 2000 degrees F. Curve B illustrates the effect when the rolling temperature was 2050 to 2100 degrees F. All temperatures were taken with an optical pyrometer.

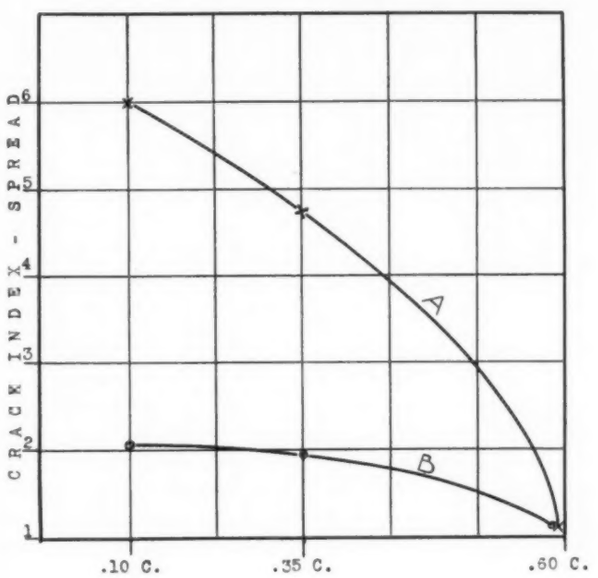


Figure 5—Curves showing relation between degree of cracking and type of steel. A: rolling temperature 1950–2000 degrees F.; B: 2050–2100 degrees F.

In curve A, it can be seen that .60 carbon grades could be rolled as low as 1950 degrees F. finishing pass temperature with normal surface on the bloom. However, this temperature was too low for the .35 carbon and .10 carbon grades for the fixed reductions taken. Curve B illustrates the decrease in bloom cracks on the .35 carbon and .10 carbon grades when the minimum rolling temperatures were raised to 2050 degrees F.

These bloom cracks, usually transverse in nature, result in longitudinal fractures on the surface of the rolled bars. If the deformation affected by the rolling is sufficiently great, they will be drawn out into long seams. If they have not been greatly affected due to light rolling action, these defects occur on the bar surface as jagged fractures.

Rolling temperatures have a decided effect upon finishing temperatures in the bar or billet mills. If the temperature at the blooming mill is too low, it is possible that small seams can result while rolling in the bar mills since the temperature will not be high enough for easy flow of the metal. This condition was noticed when rolling larger sizes of rounds and fine surface seams appeared 90 degrees apart.

It is evident that a decrease in chipping costs will result when the rolling temperatures are high enough so that the number and severity of bloom cracks are kept to a minimum.

It should be remembered that these temperatures would not apply in general to all plants, but it should bring out the fact that definite rolling temperatures must be set-up and enforced if proper control is wanted.

Here again, as in the soaking pits, the observer is a valuable aid in helping the rollers achieve the proper surface when rolling various grades of steel. If heating cycles are properly followed, and if other factors in the soaking pits are rigidly enforced, the rolling temperatures automatically should fall in line. There is no question that if minimum rolling temperatures for each grade of steel are strictly kept, minimum conditioning costs will be obtained.

CONDITIONING

Throughout this discussion no attempt was made to present actual values as to chipping rates since these values are only relative from plant to plant. The type of products manufactured, the type of rolling equipment, whether the conditioning of hot or cold blooms is made, whether direct rolling or rerolling is the practice, all have an effect upon conditioning rate and costs.

It is evident, as mentioned before, that bloom cracks are a direct comparison to chipping rates and the severity and number of these cracks affect chipping rates to a large degree. It is also evident that if the severity and number of these cracks is kept down to a minimum, that normal chipping requirements can be obtained.

The problem of conditioning is indeed more complex than many may imagine. This problem for the chipping foremen does not resolve itself into simply chipping out the surface defects, but requires them to have a very thorough knowledge of the type of steel they are dealing with, the surface requirements demanded for that particular grade, what type of finishing mill is to further process the steel bars and above all how much money can be spent per ton to keep the price structure in line.

Thorough conditioning of the bars is only possible when the scale has been removed by pickling. When surface requirements are very rigid such as in the manufacture of cold heading wire or rods, or in seamless tube manufacture it is necessary to pickle the bars if a good thorough chipping job is desired.

When chipping thin skinned capped or rimmed ingots, deep cuts cannot be taken since it is possible to break into the core of the steel bar. Upon further rolling such as in a rod mill, many small surface seams will occur. Excessive corner chipping on this type of bars makes it

impossible to achieve good rollings in the finishing hot mills.

On killed grades, deep surface seams require deep chipping and unless the edges are rounded, there is always danger of laps being formed in further hot rolling. This type of chipping is especially undesirable on rounds for seamless tube manufacture that are to be processed on very fast piercing mills.

The main consideration in conditioning steel bars is the cost per ton. There are products where chipping cost must be kept to a minimum because of price structure. The main difficulty lies in the fact that in this group fall many grades that demand an exceptionally good surface.

It is very evident that control of the conditions which affect the surface of the rolled bars must be practiced since certain difficult problems are obtained in the chipping yard.

SUMMARY

The condition of the steel ingot before it is charged into the soaking pits has a great influence upon subsequent, semi-finished surface quality. A few of the controllable factors in the open-hearth, which lead to normal surface results, have been discussed, and some of these factors, which are under the control of the soaking pit operators, have been presented.

Attention has been called to the necessity of controlling soaking pit operations with definite time-temperature cycles if minimum conditioning is to be possible.

The influence of optimum rolling temperatures upon surface quality has been emphasized.

A few factors influencing the chipping yard foremen when conditioning steel bars or billets have been given.

In conclusion, it should be considered that no one single factor will guarantee good surface quality, and it is only by very close cooperation of the open-hearth and blooming mill departments that quality products can be produced at a minimum operating cost.

DISCUSSION

PRESENTED BY

E. E. CALLINAN, *Combustion Engineer,* Steel and Tube Division, Timken Roller Bearing Company, Canton, Ohio.

G. M. COUGHLIN, *Combustion Engineer,* American Rolling Mill Company, Ashland, Kentucky.

A. J. FISHER, *Fuel Engineer,* Bethlehem Steel Company, Sparrows Point, Maryland.

G. R. McDERMOTT, *Vice President,* Surface Combustion Corporation, Toledo, Ohio.

C. L. LABEKA, *Plant Metallurgist,* Pittsburgh Steel Company, Monessen, Pennsylvania.

W. B. FARNSWORTH, *Chief Metallurgist,* Pittsburgh Steel Company, Monessen, Pennsylvania.

R. I. GUMAER, *Combustion Engineer,* Jones and Laughlin Steel Corporation, Pittsburgh, Pennsylvania.

E. E. CALLINAN: Mr. Labeka's paper covers very completely the relationship between soaking pit operations and the surface condition of the steel. At our plant, where all our product is killed steel of high and low alloy content, we encounter the same problems and strive to apply the same solutions as Mr. Labeka does in the rimmed or semi-killed grades.

It might be added that the practices he recommends from the standpoint of surface quality are of equal importance to good internal structure and quality. Such items as segregation, internal cavities of various types, pattern, and uniformity of structure can be greatly helped by giving proper attention to the factors Mr. Labeka has discussed.

G. M. COUGHLIN: The difficulty is that most of the plants are not equipped with sufficient pit capacity to do all the things desired. If we do what the production man wants, then the metallurgist and inspection department are on our necks. If we do what the metallurgist and inspection department wants, then the production department is on our necks. So we are between the devil and the deep blue sea. I think that is the condition of most of us. We all want to prepare our steel properly, but customers must be satisfied, too, as to delivery dates.

A. J. FISHER: I would like to re-emphasize the temperature of rolling, which, as Mr.Labeka has shown and pointed out, should be high. We, at Sparrows Point, roll at a little higher temperatures than he has shown. We try to get up to 2300 to 2450 on lower carbon steels, and by this practice we have been successful in eliminating a lot of our steel surface defects.

G. R. McDERMOTT: I would be interested to learn whether the author has conducted any experiments to determine whether beneficial results may be obtained in a definite controlled rate of cooling of blooms, particularly alloy blooms. Possibly surface cracks encountered in blooms may be due to improper rate of cooling and not improper soaking pit practice.

C. L. LABEKA: We have definitely found that surface cracks are produced by too rapid a rate of cooling. This is especially true in the higher manganese and alloy grades. We do not have special cooling pits that have controlled cooling equipment and we have not tried cooling under control by placing the blooms in the soaking pits since sufficient pit space has not been available.

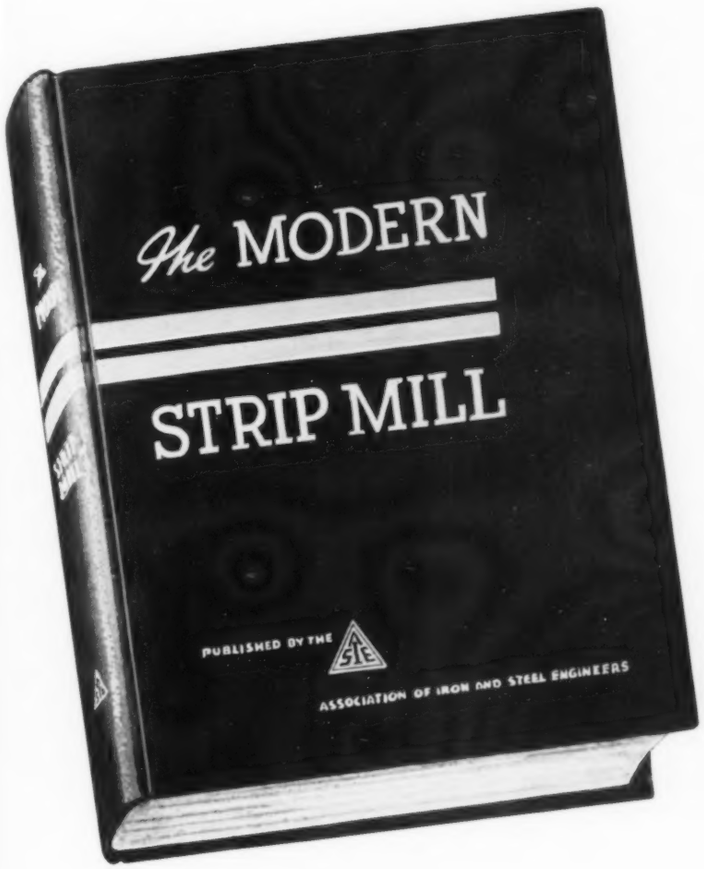
It is logical to assume, however, that since controlled heating of cold ingots and blooms has proved beneficial that controlled cooling of the hot blooms would likewise prevent surface cracking that is due to improper cooling rates. We have slow cooled steel by covering with granulated slag and this has prevented, to a large extent, cooling cracks appearing on the steel surface.

G. R. McDERMOTT: Have you arrived at a definite controlled rate of cooling for different steels?

C. L. LABEKA: We have not tried any definite cooling cycles, but as I mentioned, a rough method such as cooling in granulated slag has shown promising

(*Please turn to page 60*)

For A. I. S. E. Members in **1941**



Continuing the Association's policy of keeping its members well-informed, "THE MODERN STRIP MILL" has been prepared and will be presented to all members as of July 1, 1941.

Great care has been exercised in the preparation of this work so that information contained therein will be of permanent value. Strip mill practice, as followed in the wide strip mills in the United States, has been carefully described in the first part. In the second part, available data on all of the 28 individual installations have been tabulated in a thorough and complete manner. Contained within each section is detailed catalogue information that has been prepared by the suppliers of steel mill equipment and services.

An attractive, permanently bound volume of over 400 pages, "THE MODERN STRIP MILL" will be a valuable addition to the progressive engineer's library. It represents the first handbook presentation of any branch of the steel industry, and the information therein is available from no other source. Reserve your copy now by making application for membership in the Association of Iron and Steel Engineers.

"THE MODERN STRIP MILL"

PART I—Equipment and Process

SECTION I—GENERAL
Product—History—Installations—Capacity—Steel quality—Process—Selection of mill size.

SECTION II—SLAB HEATING
Slab yard—Slab heating furnaces—Depiler—Charging table—Pusher.

SECTION III—HOT STRIP MILL
Stand spacing—Roughing scalebreaker—Roughing stands—Turntables—Slab pusher—Slab squeezer—Edgers—Universal roughers—Crop shears—Finishing train—Mill speeds—Loopers—Screwdown—Roll balance—Guides—Drafting—Strip temperature—Rolling pressure—Hot mill operation—Disposal of product—Flying shears—Coilers—Mill tables—Descaling.

SECTION IV—MILL PARTS AND ACCESSORIES
Housings—Rolls—Roll changing—Cold mill roll grinding—Gear sets—Lubrication—Bearings.

SECTION V—ELECTRICAL EQUIPMENT
Rolling power calculations—Energy saving—Mill drives—Motor room design—Motor room ventilation—Power supply.

SECTION VI—PICKLING
Continuous pickling lines—Batch pickling.

SECTION VII—COLD MILLS
Tandem mills—Reversing mills—Reductions—Maintenance of gauge—Strip tension—Mill speed—Coolant—Rolling power calculations—Data from typical mills—Temper mills.

SECTION VIII—HEAT TREATING
Annealing—Normalizing.

SECTION IX—PROCESSING AND MATERIAL HANDLING
Shearing, etc.—Galvanizing—Electrolytic cleaning—Tinning—Cranes—Trucks—Conveyors.

PART II—Mill Descriptions

This part contains available data on each of the 28 wide strip mills installed in the United States. Complete tabulations and mill layouts are included.

THE ASSOCIATION OF IRON AND STEEL ENGINEERS
1010 EMPIRE BUILDING, PITTSBURGH, PA.

Hot Strip COILERS *and their* DRIVES

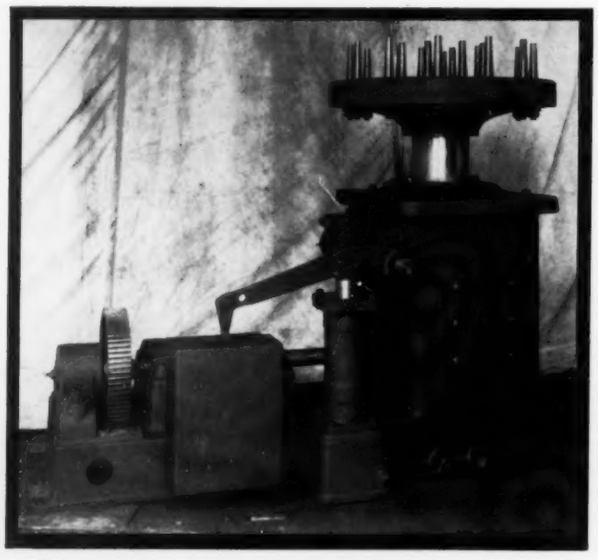
By R. A. Geuder, Manager
Metal Industry Applications
RELIANCE ELECTRIC & ENGINEERING COMPANY
CLEVELAND, OHIO

Presented before A. I. S. E. ANNUAL CONVENTION
CHICAGO, ILLINOIS, SEPTEMBER 24-27, 1940

▲ THE demand for strip steel has been ever increasing due to developments in the automotive industry and in other fabricating industries. Obviously the use of a continuous strip of metal eliminates the necessity for frequent handling of the material. Of course, the very early continuous strip mills or mills which made a continuous strip of metal were not particularly influenced by requirements for wide strip. Consequently the coilers used for the early continuous strip mills did not present any of the multitude of problems that are present on the modern mills.

The use of more and more steel for automobile bodies, probably more than any other one factor has increased the demand for flat strip and sheets. Moreover, there has been a continuous trend in the direction of fabricated shapes instead of rolled shapes, with the result that the strip mills have relieved the old merchant mills of much of the tonnage that went into small structural shapes.

Figure 1—In the pin type coiler, the strip end is engaged between any two pins, and the strip is wound around the outer diameter of the pins.



Whether the market is for hot-rolled strip or cold-rolled strip, the mill must produce it in coil form, not only for the ease of handling but also to obtain economically the annealing that may be required to produce the desired physical properties.

Even now the hot strip mills are not capable of producing the size of coils that can be most economically handled. This may be due to limitations in the slab capacity, furnace capacity, mill capacity, metallurgical requirements, or it may be a limitation in the hot strip coiler itself. In any event, in many of the mills the product from the hot strip coilers is being welded together in two or three lengths to produce a large coil which can be more economically handled on the pickle lines, cold reduction mills, shearing lines and slitting lines.

Probably the first hot strip coiler in America went into operation at the Acme Steel Products mill in 1918. This coiler handled material 3 in. wide at a top lineal speed of 2000 ft. per min. From that early date the hot strip mill coiler has steadily been improved, and modified until now there are probably 100 hot strip coilers in operation all over the country, some handling steel up to 94½ in. in width and some at top speeds up to 4000 ft. per min. Wide strip mill top speeds are approximately 2100 ft. per min. Of the flat products produced in the steel mills of this country in one year, probably the total tonnage which is coiled on hot strip coilers amounts to about 9,000,000 tons. Gauges in steel ranging from 20 gauge up to ¼ in. thick can be successfully coiled hot.

In the demand for hot strip in coil form, there has naturally arisen certain requirements and economic situations which influence the type of coiler that may be applied to a particular product. Progress throughout

recent years has also done much to influence the kind of coiler that might be used and the practical results that have been obtained. Several types of coilers are available and each has its own particular reason for existence and probably each has a logical place in the industry. There are upcoilers which, as the name implies, coil the strip above the line of flow of the material. There are pin or paddle-type coilers which wrap the strip on a series of pins. Usually this coiler is operated in the horizontal position with the material standing on edge. There are the downcoilers which are subdivided into two groups, namely, the internal expanding type and the mandrel type.

It will not be the purpose of this paper to advocate the use of any particular type of coiler for a particular type of application, but an attempt will be made to present the facts in what appears to be the general usage and results of the various types as applied in the industry.

The pin or paddle type coiler is illustrated in Figure 1. It will be noted that the end of the strip is engaged between any two of the pins and the coiler winds the strip around the outer diameter of the pins. This type of coiler is frequently used on skelp for continuous pipe mills and the strip is frequently wound vertically, that is, the strip on edge. In operation, the coiler is driven by an adjustable-speed direct-current motor. Frequently this main-drive motor is an industrial type and the decreasing speed on the pin-type coiler as the coil increases in diameter is under the control of the operator and is not usually automatically controlled. The operator uses a multi-point master switch with which to vary the coiler speed. After the coil is complete, the pins drop below the surface on which the coil is resting and the coil is pushed off onto a conveyor. It is general practice to have two or more of these coilers available with a distributor sending the strip to that one which is ready to receive it.[1] This particular type of coiler

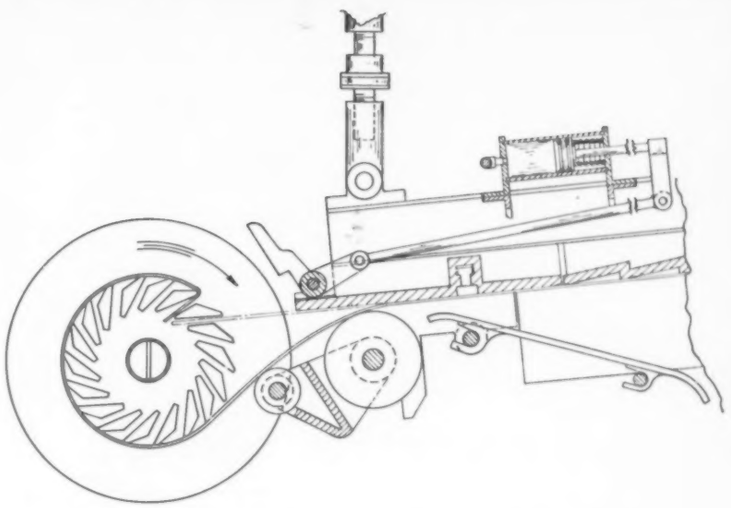


Figure 3—Sketch showing general arrangement of a horizontal paddle type coiler, arranged to feed strip to the coiler with the coiler rotating.

Figure 4—In this typical installation of the horizontal paddle type, the operator must slow down the 100 hp. d-c. drive motor as the coil builds up.

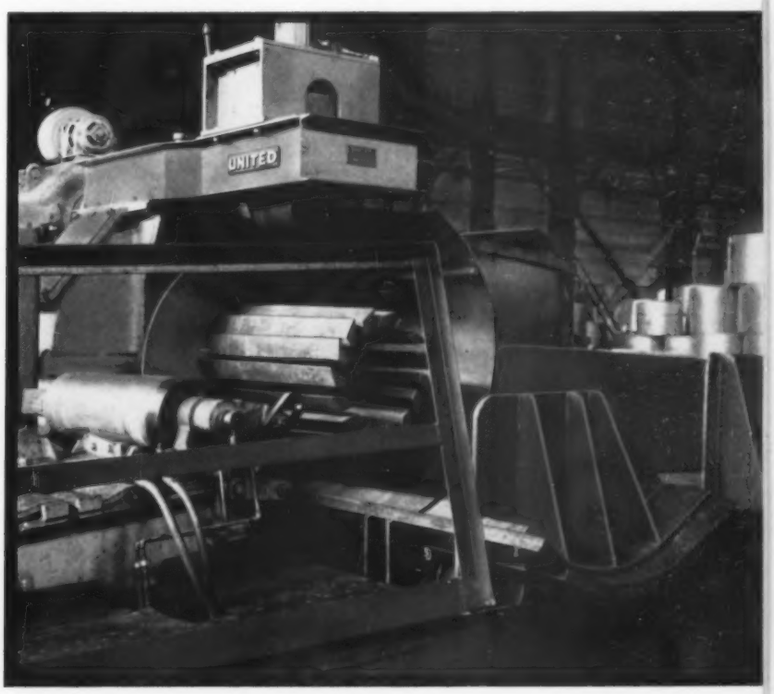
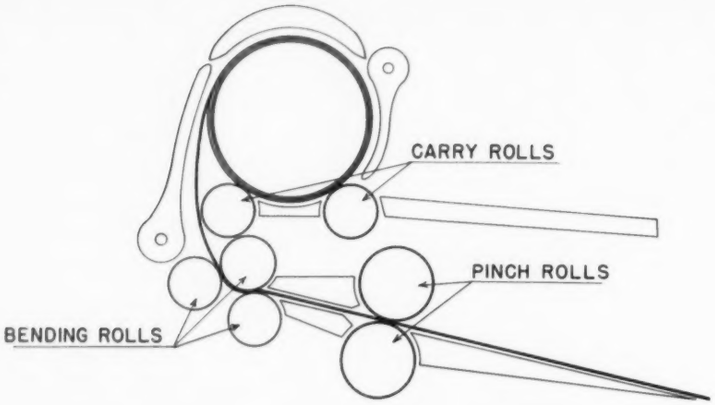


Figure 2—The pin or paddle type coiler is widely used for the vertical coiling of skelp and the narrower strip.



ARRANGEMENT OF HOT STRIP UPCOILER

represents a relatively inexpensive piece of equipment and is frequently confined to winding of strip less than 12 in. wide. A notable exception of this rule, however, is a recent installation in the Chicago district where it is expected that a coiler such as this will handle strip up to about 30 in. wide.

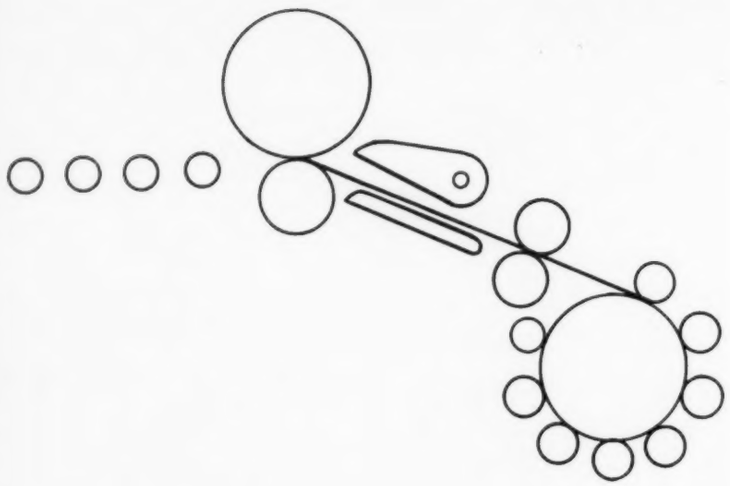
The horsepower requirements on a pin coiler vary quite widely but probably all of them fall within a range of about 25 to 100 hp., depending to a certain extent on the speed of material but equally influenced by the rms. load on the motor due to the frequent starting and stopping requirement imposed on the drive in addition to the normal coiling load. Figure 2 shows a typical installation of such a coiler. In some instances the bed is not truly horizontal but is sloped to one side in an effort to keep the coil tight by adding the weight of the coils to the tension in the strip. Notice also that in general on this type of coiler the material is not in the mill and the coiler at the same time, but is frequently accumulated as "Christmas candy" on a table between the mill stand and the coiler.

Figure 5—(Top) Schematic arrangement of the several rolls in the upcoiler.

Figure 6—(Middle) View of upcoiler installation with overhead set of guiderollers.

Figure 7—(Bottom) General arrangement of the rolls of a typical internal expanding type downcoiler.

Figure 8—(Right) View showing the discharge side of an internal expanding type downcoiler.



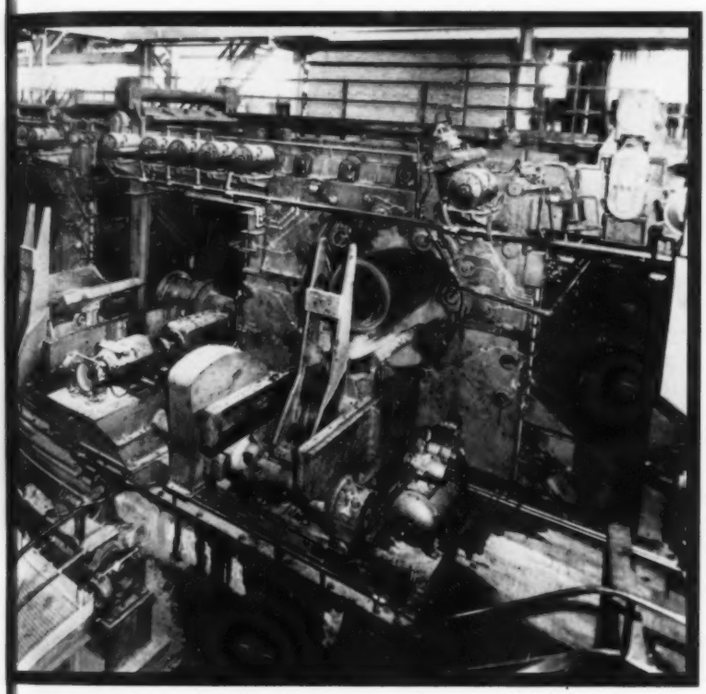
TYPICAL DOWN COILER

The paddle-type of coiler is very similar in character and appearance to the pin-type coiler and has been used recently in connection with narrow continuous hot strip mills wherein heavy gauge material at relatively low speeds and medium widths up to 24 in. could be economically handled on this type of equipment. In this case the coiler can be running and strip can be fed to it at mill speed. Figure 3 illustrates the general arrangement of the paddle type coiler which is quite similar to the pin type except that it will be noted that there is incorporated in the design an arrangement to feed the strip to the coiler with the coiler rotating. On installations of this paddle-type of coiler to date there has not been any attempt made to electrically control the tension as the coil is being wound and as it increases in diameter. Adjustable-speed type of direct-current motors are applied directly to the paddle spindle through suitable gearing and the operator is required to slow down the motor as the coil builds up in diameter. Very likely for good practical results this type of coiler is not applicable to high speed mills for obvious reasons. It does represent nevertheless a rather expensive piece of

equipment and will serve to coil that type of material best suited to it.

Figure 4 shows a typical installation of this paddle type of coiler which in this case is operated by a 100 hp. direct-current motor. Other installations have a range of from 25 to 50 hp. adjustable-speed direct-current motors operating off the mill bus.

The use of upcoilers took place fairly early in the development of hot strip mills. Space limitations and the simplicity of equipment probably influenced their selection quite strongly. Figure 5 illustrates the schematic arrangement of the several rolls in the upcoiler. Notice that the strip in coming through the lower pair of rolls is given an initial bend which is, of course, more effective on cold material than hot. Therefore, on most hot strip upcoilers there is the necessity for the overhead set of rollers which help deflect the strip around in a circular direction and to a certain extent establish the



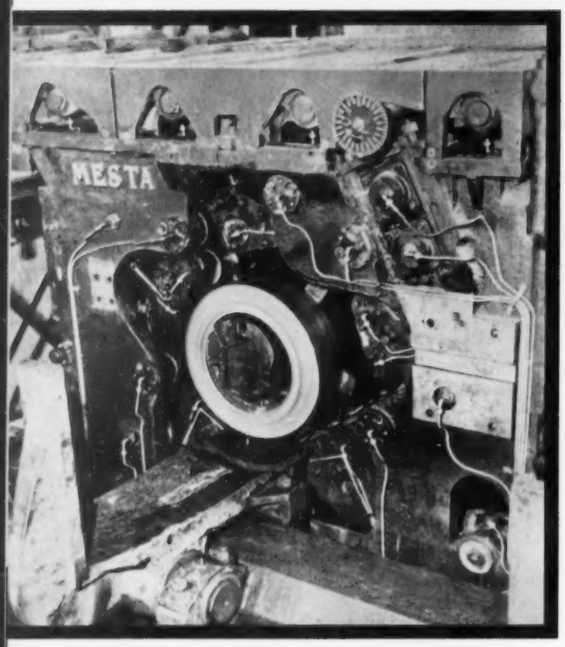
inside diameter of the coil. It is obvious that the diameter of the coil will be influenced by the stiffness, width, gauge, etc., of the material itself. However, very likely it is true that on the same material the same inside diameter of coil can be substantially maintained. These coilers are probably limited to slower speed mills and in general are not considered as good on control of physical properties of the material as related to pack annealing or surface conditioning by the application of water and so on. Figure 6 shows a photograph of a typical installation of an upcoiler with the overhead set of guide rollers. Adjustable-speed direct-current motors upwards of 125 to 150 hp., with a speed range to match the mill speed, are used. There is, of course, no necessity for the control of speed for coil build-up. Naturally on some installations motors of less horsepower can be used. It is necessary for the motor to start and stop for each coil and most installations of these coilers consist of two so that they can be used alternately.

Probably in recent years the most popular type of coiler for the high speed wide continuous hot strip mills has been the downcoiler. There are two types, namely, the internal expanding type and the mandrel type. The internal expanding type is older than the mandrel type and has been in successful operation in a great number of mills. These particular types of coilers have handled not only the widest strip but also the highest speed wide hot strip mills. Figure 7 illustrates the general arrangement of the rolls of a typical internal expanding type of downcoiler. It will be noticed that the strip is guided through the throat of the coiler and down into the cluster of rolls. These rolls are all rotating at a surface speed probably about 10 per cent above the speed of the strip coming to them. The strip is, of course, directed around inside the cluster and begins to wind up layer on layer. On certain types of these coilers the mandrel in the center of the coil determines the inside diameter of the coil that is being wound. In other designs the inside diameter of the coil is not so accurately determined but, as in the case of the upcoiler on the same grade of material, probably the inside diameter will be repeated coil after coil.

The entry pinch rolls as well as the cluster rolls are all power-driven. On the very early coilers of this type each one of the rolls was driven through a universal joint from a common spindle gear box. The gear box was driven by a single direct-current adjustable-speed motor which could be adjusted to meet the varying delivery speed of the mill. On the more recent installations the universal joints and common gear box and spindles have been replaced by individual motor-drive. One motor is applied to each coiler roll in the cluster or to each pair of rolls, depending upon the particular design.

Referring again to Figure 7 we will see that the cluster rolls move out radially as the coil increases in diameter. The mechanisms are so designed that with the upper roll stationary the remainder of the cluster rolls will move out in such a way as to maintain a perfect circle. On some of the early types of expanding coilers the motion of the rolls outward was actuated by a motor-drive. It was found, however, that probably a more accurate movement of the rolls outward could be accomplished by the coil actually pushing them outward against an air ballast supplemented by a spring pressure. Care must be taken, however, that excess pressure is not brought to bear upon the coil while it is only several layers thick. Some designs provide a motor-driven movement of the rolls outward until a sufficient number of layers have been made. Obviously if excess pressure were present, the coil would not be round but be corrugated due, of course, to lack of strength because of the very few number of turns. The design of the coiler is such, therefore, that it has to allow sufficient strength of coil to have been developed before it actually begins to push the rolls outward.

An interesting development has taken place in connection with these types of coilers and that is the introduction of what is called the deflector pinch roll. This deflector pinch roll with the large diameter roll on top and the smaller diameter on the bottom has a tendency to give the fishtail end of the strip a curvature downward to assist in guiding it through the throat of the coiler and subsequently into a coil. The deflector pinch



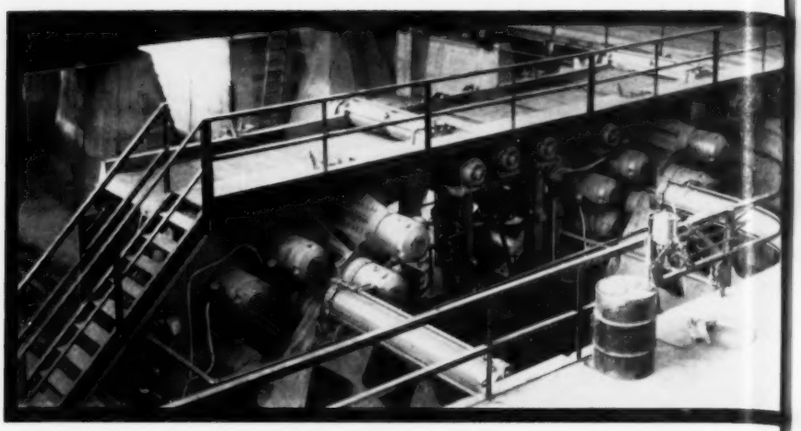


Figure 9—(Left) In this downcoiler, the mandrel guides the end of the coil as the coil is started, and serves as a support when discharging the coil.

Figure 10—(Above) This view of a downcoiler installation shows the various motors driving the coiler rolls.

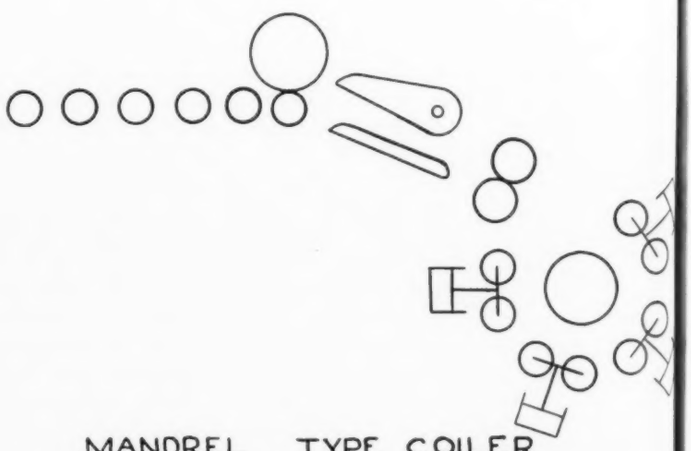
rolls can very readily be used also as a means of pulling a cobble out of the coiler in case one develops. The deflector pinch rolls may serve as a means of producing tension as the coil is formed.

Various kinds of coiler rolls have been used and probably hard cast-alloy rolls of nickel iron have proven to be about the best answer. Also to assist in guiding, several of the rolls are grooved rollers instead of being perfectly flat. This has a tendency to prevent cobbles because the guides can be interlocked and, therefore, lessen the possibility of the oncoming end to get fouled.

In connection with the production of hot rolled coils, the control of physical structure of the steel is of the utmost importance. The distance that the coiler is set back from the mill has much to do with the temperature of the steel while it is being coiled. However, because of the extremely high speed mills and because of certain physical characteristics that are desirable, much has been done in the way of directing water spray against the strip, both from above and below as it passes on its way to the coiler from the hot strip mill. In addition there has been a great deal of development in the direction of introducing water not only on the top of the coil as it is being wound up, but also between the coils. The theory here is that the water is quickly turned into steam which acts as a blanket between the layers and prevents them from scratching. In addition, of course, the metallurgist and operators will tell us that the water spray helps to set the grain structure and to assist the cold reduction mills in obtaining the physical characteristics that the user may require.

The motor drive on the several coiler rolls has steadily increased from 5 or 7½ hp. motors up to as high as 25 hp. motors per roll or per pair of rolls. Both a-c. and d-c. motors have been used with equal success. On the very early downcoilers because of space limitation, water-cooled a-c. motors were applied, but as the requirements for higher speed coilers handling wider strip resulted in increased horsepower demand on the coiler rolls, some additional space has been made available and on recent installations direct-current motors instead of alternating-current motors have been used. When alternating-current motors are used, the coiler speed to match the mill speed has been obtained by adjustable frequency. Quick stopping of coiler to discharge the finished coil is made possible by dynamically braking these a-c. motors by applying direct current to their stators. Where direct-current motors have been used the speed of the coiler has been controlled by variable-voltage and rapid stopping is accomplished by regenerative braking.

Figure 11—Schematic arrangement of the mandrel type coiler, which is a variation of the downcoiler design.



Figures 8 and 9 show typical installations of downcoilers from the discharge side. Notice the mandrel in the center of the coiler which guides the end of the strip when the coil is started, and which serves as a support for discharging the coil from the coiler. Figure 10 is another photograph of the opposite side of the coiler showing the various motors driving the coiler rolls.

This particular type of coiler has been very successfully used on all kinds of strip mills. Naturally a wide coiler or one used in connection with a wide strip mill may not be as applicable to narrow strip as would a coiler designed specifically for the narrow strip. This is quite obvious since the strength of the coil certainly varies directly with its width and a narrow coil might not have sufficient strength to push the coiler rolls out as the coil builds up. The result would be excessive slippage of the layers on each other, resulting in scratches, galls, snowballs, etc. Adjustments are provided so that lesser effort is required to expand the rolls, and the motor-operated method of outward movement of the rolls on some coilers is helpful, but in general some other type of coiler is probably more applicable to the narrow strip.

Some designs vary in the number of rolls all the way from 7 to 10, but probably the degree of variation is dictated by the outside diameter of the maximum and minimum coil to be handled on that particular coiler.

The second classification of downcoiler is the mandrel type. This differs primarily from the internal expanding type in that the power exerted on the strip to convert it into coil form is applied to the center of the coil rather than on the periphery of the coil as is true in the internal expanding type. Figure 11 illustrates the schematic arrangement of the mandrel type of coiler. Note that in general the deflector pinch rolls, throat and guide rolls are essentially the same as the internal expanding type. In addition there is a cluster of rolls which rests on the mandrel itself. The mandrel and the cluster of rolls are rotating at a speed of about 10 per cent faster than the strip coming to them. The end of the strip is caught in the nip between the mandrel and the first of the cluster rolls and is conveyed around the mandrel, snubbing tight on itself as soon as one or more wraps are made.

After the strip has been securely snubbed on the mandrel, the cluster rolls are backed off and the coil builds up on the mandrel in much the same way as is true on a tension reel on a cold reduction mill. The mandrel is driven by an adjustable-speed direct-current motor with field control sufficient to compensate for the increasing coil diameter to allow the motor to slow down inversely as the coil increases. Tension can be established back against the mill or against the deflector pinch rolls if they are down tight on the strip. Control is also provided so that the increasing coil diameter will be compensated without tension back against the mill or against the deflector pinch rolls. After the coil is complete on the mandrel, its driving motor is stopped, the mandrel collapsed and the finished coil pushed off onto a conveyor.

Figures 12 and 13 illustrate a typical installation of this type of coiler. Here the mandrel is driven by a 100 hp. motor and the deflector pinch roll by a second 100 hp. motor. Both motors are supplied with variable-voltage power from a motor-generator set whose voltage is varied to give a range of lineal speeds to match the delivery speed of the mill. This particular coiler is handling strip up to 48 in. wide at top speeds of 2100 ft. per min. Very likely because of the fact that the mandrel is overhung on a cantilever construction, this particular type of coiler may be limited to a maximum width of strip which might be less than the limitation on the internal expanding type of coiler where the rolls are supported at both ends.

The advantages of this type of coiler probably lie in its lesser first cost mechanically and electrically. As in the case of the internal expanding type of coiler, the introduction of water to the throat of the coiler in such a way as to get water between the layers results in less damage to the surface.

Figure 12—The mandrel is driven by a 100 hp. motor and the deflector rolls by a 100 hp. motor, both operating under variable voltage.

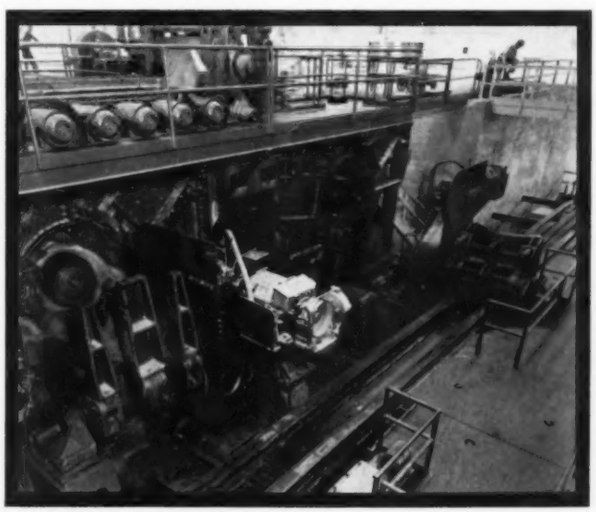
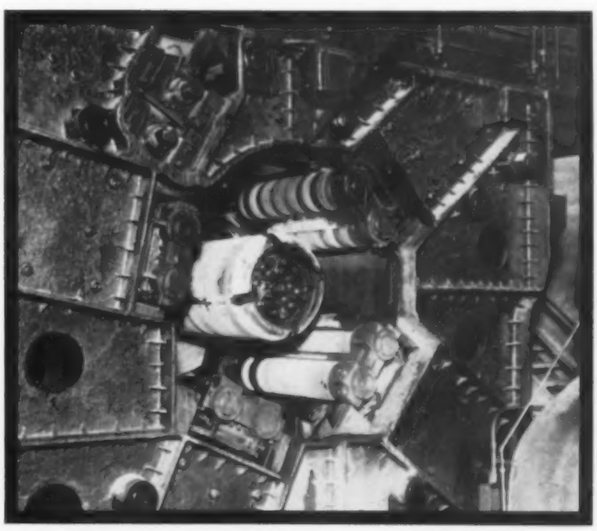


Figure 13—In the mandrel type of downcoiler, power is applied to the center of the coil rather than on its periphery.



DISCUSSION

PRESENTED BY

A. F. KENYON, Industry Engineering Department, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania.

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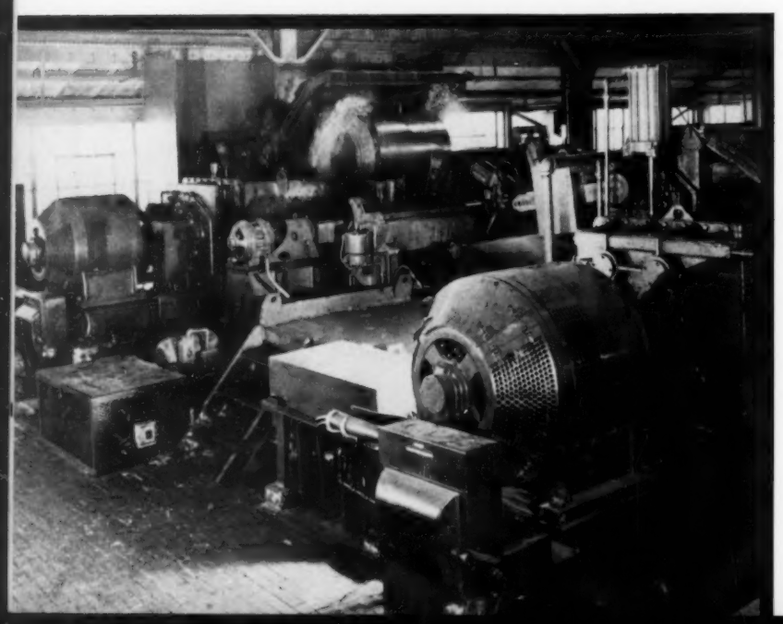
A. F. KENYON: Mr. Geuder's paper is an interesting review of the different types of coilers which have been installed at the end of various hot strip mills to coil the strip as it is delivered from the last stand of the mill, and of the developments in electrical motor and control equipment for the drive of the various types of coilers.

The paper touched only briefly on the use of upcoilers for coiling the hot strip delivered from wide strip mills, and it may be of interest to describe in greater detail the special upcoilers installed in one of the older hot strip mills which was recently widened out to 80 in. and speeded up to about 1700 ft. per min. maximum delivery speed. The two upcoilers are installed about 400 ft. from the last mill stand, and are designed to enter the strip at the mill delivery speed. The coilers handle strip from .072 in. to .250 in. thick, and from 24 in. to 76 in. wide, and the coils may be up to 16,000 lb. weight. The inside diameter of the coils is about 24 in. and the outside diameter of large coils may be 54 in.

The schematic arrangement of the pinch rolls, bending rolls, and carry rolls indicates the method of operation. The pinch rolls grip the strip as it is deflected up from the runout table, and move it forward through guides to the bending rolls. The bending rolls impart a curvature to the strip, so that it follows around inside the coiler guides and assumes the desired inside diameter. The coiler guides are moved out as the coil builds up, and the coil is supported on the two carry rolls. When the strip is completely coiled the front guide is raised, and the carry rolls are tipped so that the coil rolls by gravity down the inclined apron plate to the cross runout table which transfers the coil to the coil conveyor.



The accompanying illustration shows the drive side, with the 150 hp., 300/1200 rpm., 230 volt, d-c., adjustable speed driving motors for the two coilers. The pinch rolls, bending rolls and carry rolls are all connected to a multiple spindle gear, and driven by the one main motor. The motors are operated from the 250 volt shop system, and are controlled by reversing dynamic braking magnetic controllers.

W. B. SNYDER: Mr. Geuder has given us an excellent description of the many types of hot strip coilers, and has indicated broadly their field of application. There are one or two points, however, on which a little further elaboration may be justified.

The pin type, or vertical mandrel type coiler, which is widely used on mills producing skelp for Fretz-Moon pipe, has also been successfully applied on hot strip mills. One installation, handling 22 in. wide strip, has been in service for the last eight or ten years. Another coiler of this type, designed to handle strip up to 44 in. wide, has recently been installed on a mill in the Chicago district.

The paddle type coiler has been used on reversing hot strip mills, and in at least one installation, it has been found desirable to apply current regulators to adjust the coiler speed automatically to compensate for changes in coil diameter, and to maintain tension on the strip.

The maintenance, or rather the limitation of tension between mill and coiler is also a matter of importance on continuous hot strip mills. Practically all these mills now roll strip so long that one piece is in both the finishing stand and the coiler for a material proposition of the time, and it is the universal practice to pull the strip tight as soon as the front end enters the coiler. On the older slower speed mills the coiler motors are small, and cannot produce excessive tension under these conditions. On the newer and faster mills relatively large d-c. coiler motors are used to provide rapid acceleration and deceleration, and on these tensions sufficient to produce slippage can readily be obtained. Thus it appears desirable to provide automatic means for limiting the strip tension, to avoid slippage and scratching in the coiler. On two recent installations, current regulators are used to insure that the tension does not become excessive. These two installations have another unusual feature, in that the coilers and the tables between the mill and the coilers are arranged so that they may automatically follow changes in the delivery speed of the mill. Thus, the operators are relieved of the necessity of keeping an eye on the finishing stand tachometer, and can confine their attention to coiling and unloading.

These two features, namely, automatic limitation of tension and automatic matching of coiler speed to mill delivery speed, have proven in practice to be highly desirable, and we expect that these features will be incorporated in any future new installation, or modernization of older equipment.

Factors Affecting the Production of BLAST FURNACE GAS

Presented before A. I. S. E. ANNUAL CONVENTION, CHICAGO, ILLINOIS, SEPTEMBER 24 - 27, 1940

By J. S. Fulton

Special Representative

INGERSOLL-RAND COMPANY

PITTSBURGH, PENNSYLVANIA

▲ WHEN any iron blast furnace is in operation it is constantly producing two inter-related products, neither of which can be changed in quantity or quality for a given rate of driving without changing the other. They are the liquid pig iron leaving the bottom of the furnace and the gas leaving the top.

The primary purpose of the operation of the furnace is the production of pig iron, which is accomplished by the reduction of the ore by CO. The CO is generated at the tuyeres by the combination between the carbon of the coke and the oxygen of the blast. Before any CO can be produced a "fire" must be started and this "fire" produces both heat and the desirable CO.

Consequently then, while the primary purpose is the production of pig iron, the primary function of the process is the generation of CO. It is necessary to make this distinction between the primary purpose and primary function of blast furnace operation in order to concentrate upon the gas production phase.

The iron blast furnace will produce a top gas containing 39+ per cent by volume of CO plus CO_2 for any carbon rate with the CO/CO_2 ratio, that is, $\frac{\text{C in CO}}{\text{C tn CO}_2}$, increasing with the carbon rate. The reduction of the ore diminishes the CO produced at the tuyeres by the amount of CO transformed to CO_2 from the O_2 reduced from the Fe_2O_3. The particular amounts of CO and CO_2 appearing in the top gas is nearly constant for a given carbon rate but is altered by the presence of hydrogen.

As an illustration of the influence of the reduction of ore upon the CO/CO_2 ratio, there is a blast furnace in operation smelting phosphate rock with only a trace of iron. This furnace shows the CO as nearly 39 per cent by volume and only a minor percentage of CO_2 to cover the reduction of the trace of iron. The CO gas is produced, but little if any CO_2 is made because little ore is there to be reduced, and so the CO is found in the top gas, practically unchanged.

On the opposite extreme we can imagine a vertical shell full of ore and voids through which CO_2 is forced and no ore reduced because there is no CO and this gives the maximum amount of CO_2.

The usual blast furnace operation is somewhere between these extremes, so all that the production of pig iron does to the production of gas is to decrease the CO and increase the CO_2 in the top gas.

The pig iron production is given the most attention because it is the desired function, but possibly also because it and the liquid slag are both visible and ponderable. At the same time these two products are leaving the bottom of the furnace, the gas, both invisible and unweighed, is leaving the top of the furnace with a weight at least three times the weight of the iron and slag combined. Here is a machine which turns out two products, each of which is a by-product of the other, and neither of which can be produced without the other. With one product weighing three times the other, certainly more attention should be paid to it than in the past.

Since the reduction of the ore and the partial alteration of the CO to CO_2 are a continuous chemical reaction, it is obvious that any change in the CO/CO_2 ratio in the top gas gives an immediate report of reduction changes below, that may not be apparent at the hearth for hours. The change in the CO/CO_2 ratio is also accompanied by a change in the temperature of the top gas which also reports a change in the reduction cycle.

There is yet another phase of the furnace operation that must be considered. The CO and CO_2 appearing in the top gas indicate a previous production of heat, that was presumably sufficient to supply the heat demands for reduction of ore, calcining of limestone, liquefaction of the iron and slag, the sensible heat of the top gas, the radiation and the jacket cooling. Since we are dealing with a furnace in successful operation, which presupposes sufficient internal heat, we need not make a thermal balance but later on it will be advisable

to consider alteration in the internal heat from various causes.

Some time ago the writer became interested in the trend of the CO and CO_2 curves below an 1800 lb. carbon rate as several novel methods of furnace operation were under discussion that indicated as low as 1200 lb. of carbon per gross ton.

It has been recognized for some years that while the Brassert curves gave CO and CO_2 values well in agreement above 1800 lb., that the CO/CO_2 ratios below 1800 lb. were off. The writer felt that if the curves could be extended to include ferro-manganese furnaces that the trend of a curve between 1400 lb. and 6000 lb. carbon rates would be subject to less error in the lower ranges, than if it were developed for a shorter range.

After several false starts, consistent curves of the weight of top gas, carbonized gases and nitrogen were found to be almost exactly straight lines between 1400 lb. and 6000 lb. carbon rates. These are plotted in Figure 1.

The corresponding curves for volumes were plotted in Figure 2. At the top is plotted the per cent of nitrogen by volume and inversely the per cent of carbonized gases. Since the volume of all the gases follows about the minimum range of commercial combustibility. Also at this 1200 lb. rate the blast weight has decreased and can not carry in much heat; also the CO/CO_2 ratio has decreased and very little heat is being generated so it would be inadvisable to enrich the gas by disassociating more water to bring up the Btu. value.

All of these curves were plotted at 32 degrees F., 14.7 lb., and dry. The writer uses the term dry to cover a hypothetical furnace operation where there is no moisture present either in the solids or blast. This dryness removes the unpredictable variable, hydrogen, and simplifies the study of furnace results by eliminating atmospheric humidity, and the moisture in or charged with the solids. Of course no furnace can operate without disassociating some water vapor and so showing hydrogen in the top gas; but it is usually less than $\frac{1}{4}$ per cent by weight and so would have negligible influence on the weight of top gas.

In Figure 1 is also plotted the weights of gases from the Brassert curves (shown here as Figures 4 and 5) where the 3.5 per cent hydrogen by volume has decreased the total weight. This cause of this decrease in weight begins to become apparent when we study the nitrogen curve, where the nitrogen in the Brassert fur-

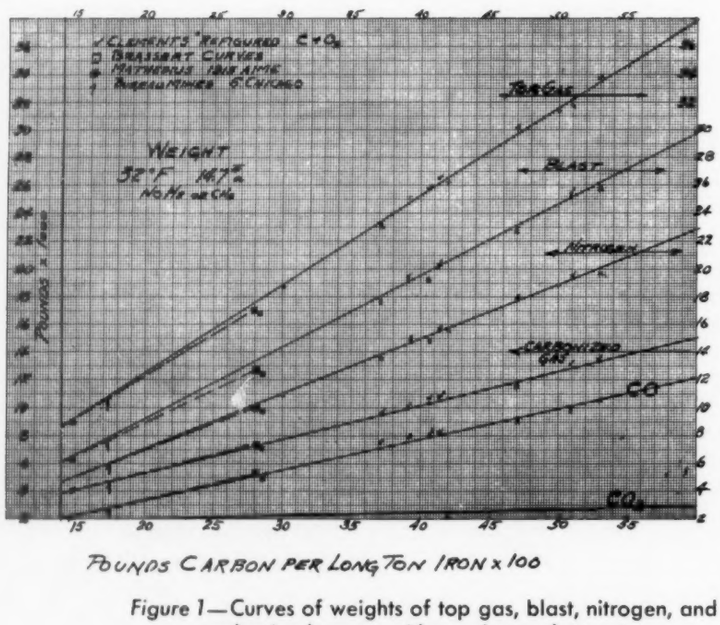


Figure 1—Curves of weights of top gas, blast, nitrogen, and carbonized gases, with varying carbon rate.

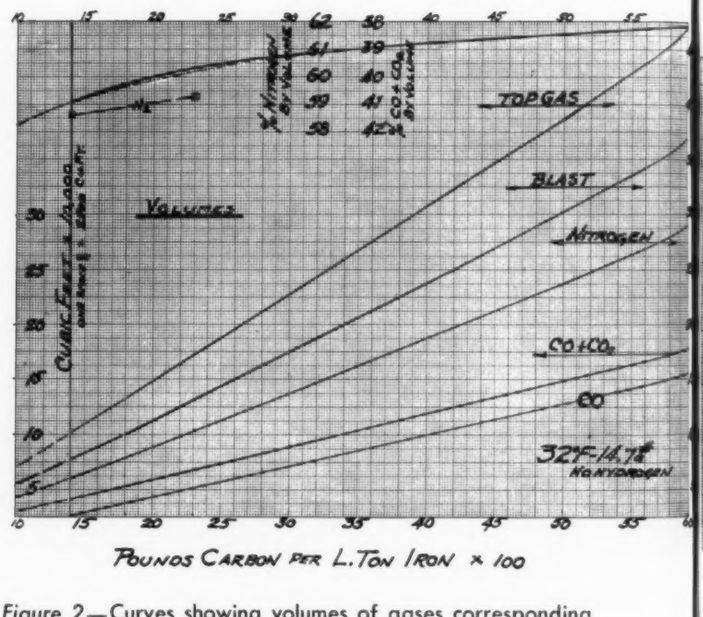


Figure 2—Curves showing volumes of gases corresponding to the weights in Figure 1.

straight line curves, striking zero somewhere below a 1000 lb. rate, the percentages by volume must be the curve shown rather than the straight line used on the Brassert curves. After this curve was discovered, an examination of the original Brassert paper showed it was equally applicable to the plotted results.

In Figure 3 is plotted Btu. per cu. ft., CO and inversely CO_2 and also cu. ft. of air per lb. of carbon. By inspection the Btu. per cu. ft. of the dry furnace will approach 80 Btu. at a 1200 lb. carbon rate and this is

nace runs about .8 per cent low, due to the disassociated oxygen accompanying the hydrogen having decreased the amount of oxygen necessary from the blast.

The characteristics of the top gas can be set up in the following equations:

A. Pounds $(CO+CO_2+N_2+H_2)$ = pounds top gas, and as a general rule the C in CO_2 of the limestone is sufficient to provide for the C in the pig iron and flue dust so the C in the equation is the carbon charged. Water vapor is neglected.

B. Pounds O_2 in $(CO+CO_2)$ = pounds O_2 in the blast and in the "solids." The O_2 in "solids" covers that in ore, in CO_2 in limestone, and O_2 from disassociated water or O_2 from any other source than from the blast.

C. By re-writing the left hand side of equation B, on the basis of atomic weights, the exchange O_2 for C, which is always known:

$$\text{Pounds C in } \left(CO\times\frac{16}{12}+CO_2\times\frac{32}{12}\right)=\text{pounds } O_2$$

in blast, and "solids."

These equations are only a mathematical statement that you can not change the weight of one item of these gases entering the furnace without making an equivalent change on the other side of the equation, because when the gases leave the top they are in chemical balance for that condition.

If H_2 is left out of equation A, its disassociated oxygen must be replaced by blast O_2, if C is unchanged, so both weight and volume of top gas go up slightly. But there is a more radical change in the Btu. per cu. ft. in Figure 3.

In Figures 6 and 7 are plotted the various gas characteristics of the dry or F furnace and the wet furnace working on the Brassert curves.

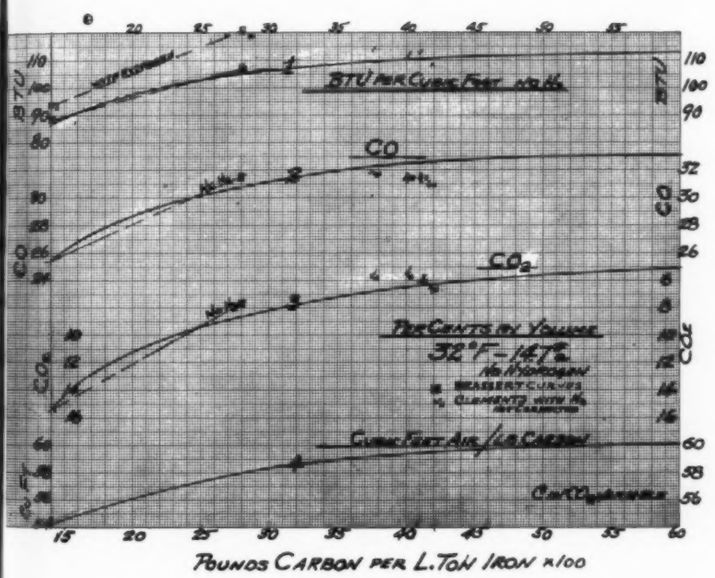
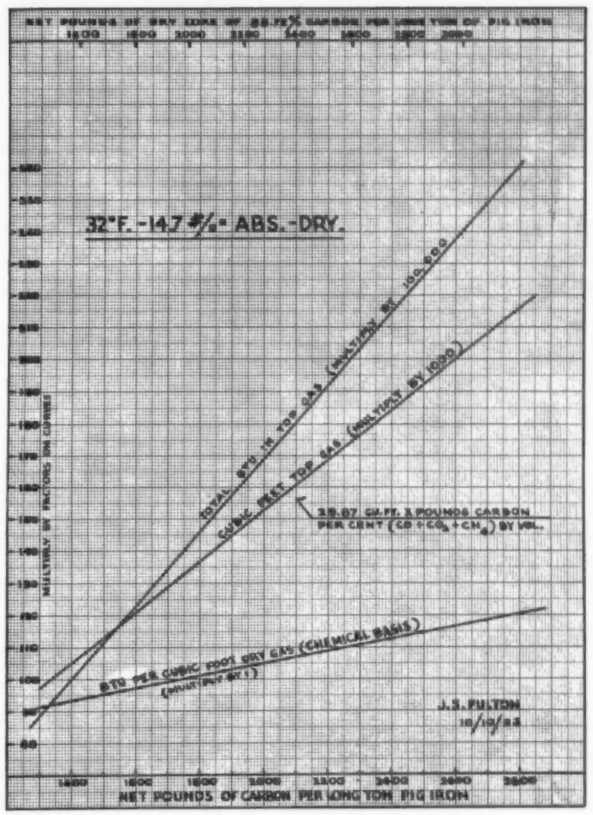


Figure 3—Curves showing characteristics of the top gas from the dry furnace at varying carbon rates.



Figures 4 and 5—The original Brassert curves shown here do not agree with practice below 1800 lb. carbon per ton of iron.

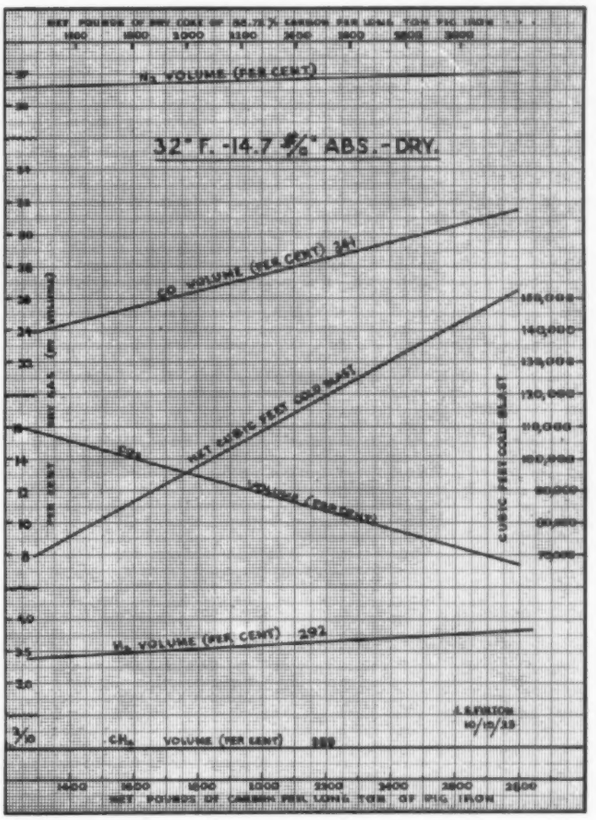


Figure 8 shows the Btu. generated in a dry furnace by production of CO and CO_2 and the Btu. per long ton for further combustion. Noted are the Btu. values for the Brassert curves for their particular amount of hydrogen. Since, according to Mathesius, something less than 13,000,000 Btu. per long ton is necessary for the heat requirements of a commercial furnace at a 1483 lb. carbon rate, it is apparent that a Fe_2O_3 furnace

is going to freeze up soon below a 1400 lb. carbon rate per long ton, as its blast weight is decreased to such a point it can not carry enough blast heat to supplement the insufficient Btu. produced by CO and CO_2.

So far we have only considered the influence of the H_2 and disassociated O_2 on the top gas production. Any other material that increases the O_2 in the "solids" such as a carbonaceous ore or more limestone will change the character of the top gas and probably the amount of O_2 from the blast.

In this study, two empirical formulae were developed, one of which accounts for the increased O_2 released from the limestone with an advancing carbon rate or a change in oxygen from water disassociated showing H_2 in top gas.

D. Pounds O_2 in solids $= 200 + 960 \sqrt{\frac{\text{carbon rate}}{1400}}$

where 960 lb. O_2 accompanies 2240 lb. Fe in Fe_2O_3 at a 1400 lb. carbon rate.

The other curve is for the amount of C in CO_2 for any carbon rate and was determined from a study of the CO_2 in the Brassert curves and ferro-manganese furnaces reported by Fred Clements. It will be noted from Figure 9 that by coincidence the C in CO_2 was 530 lb. for both 1400 lb. and 2900 lb. carbon rate on the Brassert curves, and the study was first made on the assumption that the CO_2 was constant for any rate, but this failed to agree with Clements' reports. This formula was developed and is admittedly unsupportable by mathematics but does follow the reported values. The "hump" in the Brassert values on both D and E in Figure 9 is due to the choice of straight line percentages of CO and CO_2.

The formula is:

E. Pounds C in $CO_2 = .055$ (carbon rate $- 1400) + 530$ lb.

While this formula may be in error either in its constants or form, some relation of this sort must exist on account of the constant advance of the weight of blast (oxygen). From Figure 1:

1400 lb. carbon rate—6000 lb. blast—4.28 lb. blast per lb. of C.

4000 lb. carbon rate—19,600 lb. blast—4.90 lb. blast per lb. of C.

Therefore if the CO and CO_2 were in balance per lb. of carbon at 1400, then their ratio CO/CO_2 would have to alter at 4000 lb. rate where there is $4.90/4.28 = 1.15$ times as much O_2 per lb. of carbon which can only be in balance by making more CO_2 per ton than at a 1400 lb. rate.

If this is accepted then there must be a different CO/CO_2 ratio for every carbon rate. From the previous study of the influence of the H_2 on the N_2 this basic CO/CO_2 ratio will alter depending upon the weight of H_2 per ton.

We will now study two furnaces each making 500 long tons on a 2000 lb. carbon rate and with the same amount of blast. It is found that one moves regularly and the other is irregular. Since they have the same cu. ft. of standard air per lb. of carbon they are apparently the same but one receives 200 lb. more O_2 per ton from the "solids" than the other. For simplicity we will consider this O_2 is not disassociated from water vapor and so will not have to study the thermal phase of disassociation and return.

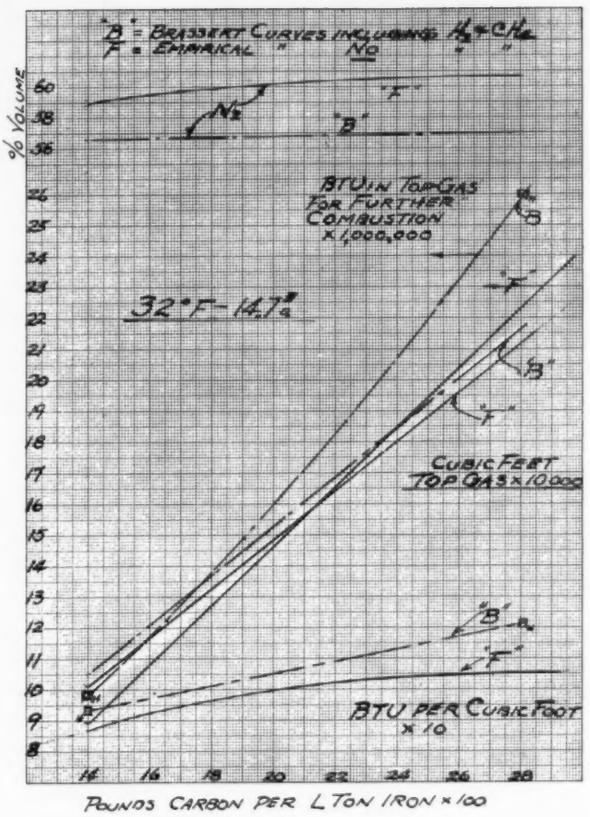

"B" = Brassert Curves including H_2 + CH_4
"F" = Empirical " " No " " "
% Volume
N_2
"F"
"B"
BTU in Top Gas for Further Combustion x 1,000,000
32° F - 14.7#
Cubic Feet Top Gas x 10,000
BTU per Cubic Foot x 10
Pounds Carbon per L Ton Iron x 100

Figure 6—Curves showing nitrogen content, top gas volume, total Btu., and Btu. per cu. ft. from Brassert curves and from dry furnace.

A Furnace

From Figure 9, there is 565 lb. of C in CO_2 or 1435 lb. C in CO and 1350 lb. O_2 in reducible form in the solids.

A. O_2 in CO + O_2 in CO_2 − O_2 solids = O_2 blast

$$1435 \times \frac{16}{12} + 565 \times \frac{32}{12} - 1350 =$$

$$1910 + 1510 - 1350 = 2070 \text{ lb. } O_2$$

$$2070 \text{ lb. } O_2 \times \frac{77}{23} = 6940 \text{ lb. } N_2$$

$$= 9010 \text{ lb. air}$$

3345 lb. CO + 2075 lb. CO_2 + 6940 lb. N_2 = 12,360 lb. top gas

6940 lb. $N_2 \times 12.7$ = 88,100 cu. ft. = 59.7%

1435 lb. C in CO × 29.63 = 42,500 cu. ft. = 28.9%

= 102 Btu.

565 lb. C in $CO_2 \times 29.63$ = 16,700 cu. ft. = 11.4%

147,300 cu. ft.

$\frac{9010 \text{ lb. air}}{.0807 \times 2000}$ = 55.8 cu. ft. air per lb. of C at 32 degrees F. and 14.7 lb.

B Furnace

Now add 200 lb. O_2 to theoretical 1350 lb., keeping blast constant at 2070 lb. O_2. Then CO and CO_2 must

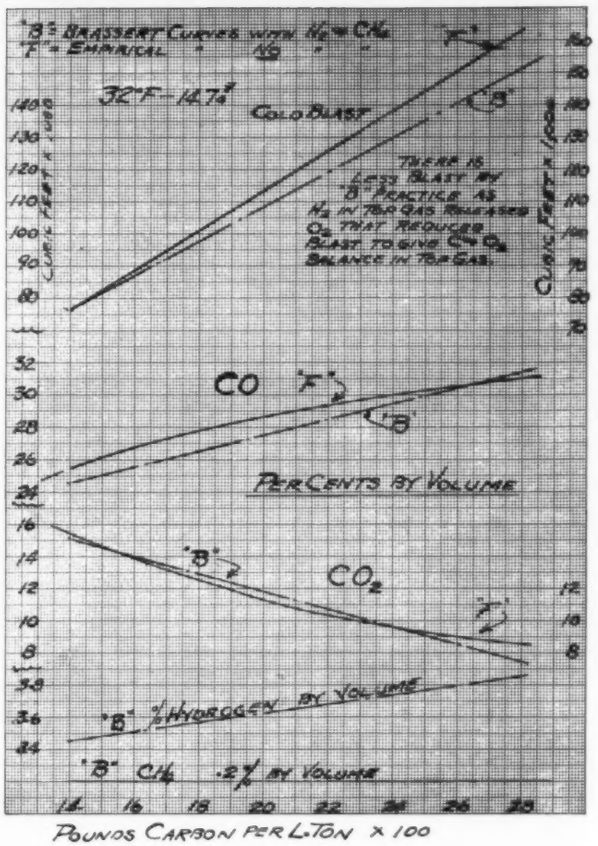

"B" BRASSERT CURVES WITH H_2 & CH_4
"F" = EMPIRICAL " " " "
32°F - 14.7#
COLD BLAST
THERE IS LESS BLAST WT "B" PRACTICE AS H_2 IN TOP GAS RELEASES O_2 THAT REQUIRED BLAST TO GIVE CO_2 BALANCE IN TOP GAS
CO
PERCENTS BY VOLUME
CO_2
% HYDROGEN BY VOLUME
"B" CH_4 .2% BY VOLUME
POUNDS CARBON PER L. TON × 100

Figure 7—Curves comparing blast volume, CO and CO content, etc., from Brassert curves and from the dry furnace.

change. 200 lb. of O_2 must be taken from CO and 200+200 added to CO_2.

B. O_2 in CO+O_2 in CO_2−O_2 solids=O_2 blast

1910−200+1510+400−1550=2070

C in CO C in CO_2

$$1710 \text{ lb. } O_2 \times \frac{12}{16} + 1910 \text{ lb. } O_2 \times \frac{12}{32}$$

1285 lb. C in CO+715 lb. C in CO_2

2995 lb. CO+2625 lb. CO_2+6940 lb. N_2=12,560 lb. top gas

6940 lb. N_2×12.70= 88,100 cu. ft.=59.8 %

1285 lb. C in CO×29.63= 38,000 cu. ft.=25.8%
=87 Btu.

715 lb. C in CO_2×29.63= 21,200 cu. ft.=14.4

147,300 cu. ft.

There is the same amount of top gas by volume, but that from *B* weighs 200 lb. more than *A*, due to increased weight of CO_2 from 200 lb. additional O_2 in solids combined into CO_2.

$$\text{Furnace } A. \quad \frac{\text{C in CO}}{\text{C in CO}_2} = \frac{1435}{565} = 2.54$$

$$\text{Furnace } B. \quad \frac{\text{C in CO}}{\text{C in CO}_2} = \frac{1285}{715} = 1.80$$

The F curves were developed with a particular balance between C and O_2 for each carbon rate and here the addition of 200 lb. of oxygen has compelled 150 lb. more of C to appear in CO_2 with a corresponding decrease in C in the CO.

At first glance the 715 lb. C in CO_2 for B, is only a 150 lb. boost and seemingly not serious, but an examination of Figure 9 shows that *B* furnace had produced as much CO_2 as a regular furnace with a 4600 lb. carbon rate due to the excess O_2 having to be balanced.

The following is the picture of what the *B* furnace is trying to do. (See curves 1 and 2 in Figure 9.)

The blast is for a 2000 lb. carbon rate.

The reducible O_2 is for a 2700 lb. carbon rate.

The C in CO_2 is from a furnace with 4600 lb. carbon rate.

In consequence of this excess CO_2 the *B* furnace will work hotter in the upper zones consuming carbon at such a rate, that the bottom zone will be starved. The excess oxygen undermines the solids, by its over active consumption of carbon, and will have a tendency to reduce and fuse the ore farther up the stack, with more hanging or channelling. So long as there was carbon available, *B* would drive faster than *A* and probably make more dust.

From time to time the subject of oxygen enrichment of the blast is discussed. The writer believes that the proper way to determine the change in gas analysis or thermal balance for partial enrichment is to go to the extreme of a furnace having nothing but oxygen in its blast, so there will be no nitrogen nor hydrogen and the carbon rate will remain the same. While one of the claims is the saving of coke, its possibility will not be considered. Only the gas and thermal phase will be studied and no changes will be considered in the metallurgical phase.

Equation A now becomes:

Pounds (CO+CO_2)=pounds top gas

Since neither the weight of C or O_2 are changed, then Equations B, C, D and E are unchanged.

Assume a 2500 lb. carbon rate where the Brassert and dry curves are in agreement. Then from Figure 3, there was 9.4 per cent CO_2 and 30.2 per cent CO by volume in the top gas including N_2. Now that N_2 has disappeared the new top gas will be (9.4+30.2)=39.6 per cent of 187,700 or 74,300 cu. ft. per gross ton, all of which is carbonized gas. 30.2/39.6=76.3 per cent new volume of CO. Then .763×341=261 Btu. per cu. ft.

261 Btu.×74,300 cu. ft.=19,320,000 Btu.

Figure 8 dry furnace=19,300,000 Btu.

The CO/CO_2 ratio is unchanged so there should be no greater activity of reduction. Since there is the same carbon rate and the CO/CO_2 ratio is unchanged, no more heat is generated within the furnace, and as seen above no more Btu. are available per ton in the top gas for further combustion.

Since the N_2 is eliminated, the blast weight is decreased 77 per cent and if the hot blast is to carry in the same Btu. per ton, the hot blast will have to be at some impossible level. If 1200 degrees F. was carried before, then since only the O_2 is left to carry this heat, the hot blast temperature will have to be roughly 1200/.23=5200 degrees F.

The weight of gases leaving the hearth will be decreased by the absence of N_2 and since the same weight

of carbon is consumed plus the blow torch action of the 5200 degree F. hot blast, there will be a tendency to elevate the zone of fusion. The gases may channel and give an irregularly working furnace with excessive top temperature.

Even if it were possible to provide the 100 per cent oxygen as cheaply as the 23 per cent oxygen in the blast, there are a number of other difficulties to be anticipated. It would appear that oxygen should be handled in the same manner as in medicine, where it is used to stimulate or ease a weakened system.

While all furnaces show some hydrogen in their top gas, it is doubtful if enough attention has been paid to the difference in internal heat, and Btu. value and CO/CO_2 ratio accompanying a change in the amount of hydrogen in the top gas. If two furnaces are charged and blown the same but one shows 2 per cent and the other 4 per cent H_2 by volume at a 1600 lb. carbon rate, the latter shows 2400 cu. ft. more H_2 or approximately 16 lb. H_2. This 16 lb. H_2 has been accompanied by 128 lb. O_2. From equation A this extra O_2 can only be balanced in the top gas by making more CO_2.

Not only is the CO/CO_2 ratio changed but the very presence of hydrogen shows that water must have been disassociated by carbon somewhere in the furnace. The reaction $C+H_2O=CO+H_2$ is accompanied by a loss of heat of 8710 Btu. per lb. of carbon as compared to the desirable production of CO from the air in the blast. This is the gross loss, but the increased CO_2 restores some of the loss and the increased Btu. in the top gas gives more for the stoves, for higher blast heat.

The hydrogen comes both from the water accompanying the blast and accompanying or added to the solids. If no water is added to the solids, then as a generality the blast furnishes from ⅓ to ½ the hydrogen. While it is customary to add water to fine ores or flue dust, it is interesting to note that one plant has blown with uniform blast moisture, by adding steam between the blower and the stoves.

With so many factors influencing the CO/CO_2 ratio, the N_2, the Btu. per cu. ft., the volume of top gas per ton, etc., it is apparent that no true comparison can be made between the gas analysis of two furnaces unless every source of carbon and oxygen is considered. The Brassert curves have served their purpose for a long time and the weights of top gas and blast per ton shown in Figures 4 and 5 are sound for the particular practices plotted. However in showing CO, CO_2, N_2 and H_2 as per cents by volume of top gas, as curves, an error of judgment chose the per cents by volume as "straight line curves." As plotted on Figure 1 the weights of the gases followed "straight line curves" as of course did the volumes in Figure 2. The relation between two such curves can not mathematically be a straight curve but must assume a form similar to the N_2 and $(CO+CO_2)$ curve at the top of Figure 2.

After the curve of Figure 2 was developed a study of the original Brassert paper showed that this "curve" was just as applicable to the plotted analysis as the "straight line curve" chosen. While the F curves were developed without hydrogen the addition of hydrogen will have little influence on the weight of top gas as it is considerably less than 1 per cent by weight in any of the analyses studied. While hydrogen, from its lightness, will increase the total volume of top gas a few per cent, it must be remembered the alteration of CO to CO_2 does not change the total volume of carbonized gas and the nitrogen has been assumed to be constant.

As is seen in Figure 3, the choice of the straight curve gives too low a percentage of CO (and too high CO_2) at or below an 1800 lb. carbon rate.

The writer believes there is enough accurate top gas analyses in existence, in the records of the different plants, to develop a new set of curves applicable to modern practice. Since no furnace runs in an arid region then some moisture must enter the furnace and be disassociated. Every lb. of hydrogen releases 8 lb. of oxygen, when water is disassociated, so it will be advisable to develop at least three sets of curves for say, 20, 30 and 40 lb. of H_2 per long ton. Unless this is done, a furnace with moist solids and high blast humidity, for the same carbon rate, will not show the same percentages N_2, CO, CO_2 or H_2 in the top gas. We would not expect to match analyses at different coke rates. We can not match analyses unless in addition, the H_2 is the same.

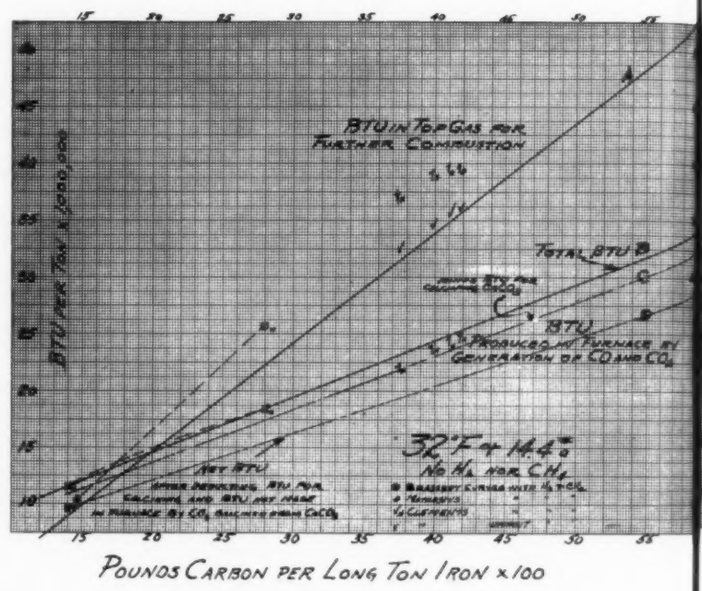

BTU IN TOP GAS FOR FURTHER COMBUSTION
TOTAL BTU
BTU PRODUCED IN FURNACE BY GENERATION OF CO AND CO2
32°F + 14.4 gr
No H2 nor CH4
POUNDS CARBON PER LONG TON IRON x 100

Figure 8—Curves showing Btu. produced in dry furnace by generation of CO and CO_2, and Btu. in top gas.

In the development of the necessary blast volume, or weight, for these new curves, it must be recognized that the present standard method of compensating local barometer and air temperature tends to furnish more oxygen to the hearth than contemplated. In referring the blast volume to 60 degrees F. and 29.92 in. Hg barometer no consideration is given to the oxygen in the water vapor in the atmosphere. As now compensated the air is blown as if absolutely dry, which would not exist even at −60 degrees F.

The writer urges that for accuracy the blast be determined on the basis of lb. of total oxygen, including that in the water vapor. First, no furnace ever receives absolutely dry air, and second, a cu. ft. of air saturated with water vapor has more oxygen (including that in the water vapor) than has a cu. ft. of dry air at the same temperature and barometer.

From pages 610–613 of the 1929 edition of *Hand Book of Chemistry and Physics* the following values are obtained, based upon there being 23.15 per cent O_2 in a lb. of dry air and 16/18 or 88.89 per cent O_2 in a lb. of water or water vapor. At 60 degrees F. and 29.92 in. Hg a cu. ft. of dry air weighs .0764 lb. and has 123.80 grains O_2.

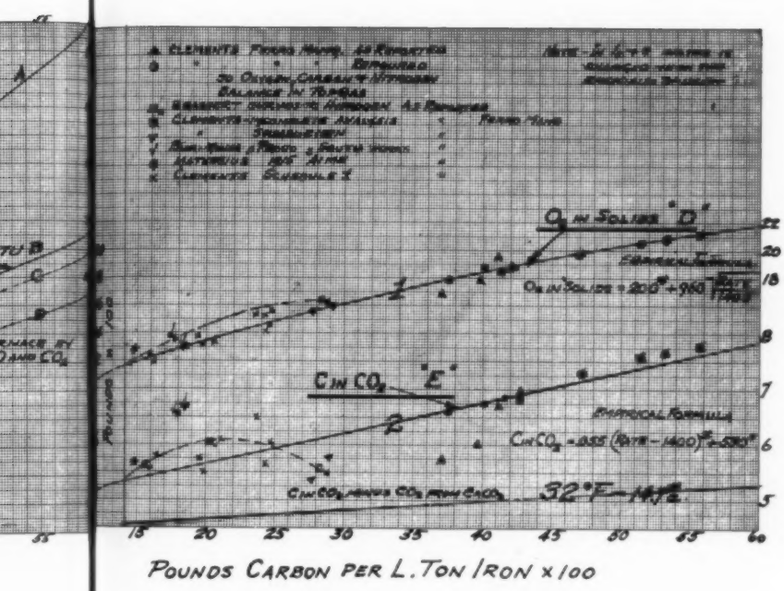


Figure 9—Curves from which were developed empirical formulae for oxygen in the solids and for carbon in CO_2.

If saturated at 60 degrees F. and 29.92 in. per cu. ft. dry air weighs .07506 lb., vapor weighs .00083 lb., and the mixture weighs .07589 lb. But dry air contains 121.55 grains, vapor contains 5.17 grains, and the mixture contains 126.72 grains O_2. This is 2.4 per cent excess O_2 in blast.

It is customary to correct the volume at the particular barometer and air temperature as if blown to 60 degrees F. dry bulb and 29.92 in. Assuming a furnace working at 90 degrees F. saturated and 29.00 in. barometer, the factor would be:

$$1.0\times\frac{460+90}{460+60}\times\frac{29.92}{29.00}=1.0912$$

At 90 degrees F. saturated and 29.00 in. dry air weighs .06657 lb. per cu. ft., vapor weighs .00213 lb. per cu. ft., and the mixture weighs .06870 lb. per cu. ft. But dry air contains 109.53 grains O_2 per cu. ft., vapor contains 13.26 grains, and the mixture contains 122.79 grains O_2 per cu. ft.

Grains O_2 per cu. ft. 60 degrees F.—
29.92 in. dry 123.80
Grains O_2 per cu. ft. 90 degrees F.—
29.0 in. saturated 122.79

1.01

In other words there is within 1 per cent of the same weight of O_2 per cu. ft. in either of these extreme conditions.

When the blast volume is increased 9.12 per cent the blast O_2 is increased to the equivalent of $\frac{122.79\times1.0912}{123.80}$ = 134.0 grains, which gives an excess of 8.2 per cent O_2.

Of course furnaces are seldom blown in this country for any length of time with 90 degrees F. saturated air but it is interesting to note that one southern practice blows about 5 per cent less "standard air" in summer than in winter.

The question is asked, "What would have been the operating furnace results if the blast volume had not been increased 9.12 per cent and 8.2 per cent extra O_2 had not been supplied?"

In passing it is interesting to note that if a furnace were blown at 40 degrees F. saturated, 29.0 in., it would receive 125.25 − 123.80 or 1.45 grains O_2 excess or 1.2 per cent excess O_2 after the customary correction for barometer and inlet air temperature had been made.

Since in the broadest sense the top gas production of a blast furnace is a report of all the previous chemical combinations, then for accuracy in the study of gas analyses, every pound of carbon and oxygen that enters and leaves the furnace in a reducible, or combinable, form must be accounted for.

DISCUSSION

PRESENTED BY

R. A. LINDGREN, *Superintendent of Blast Furnaces*, Wisconsin Steel Works, International Harvester Company, Chicago, Illinois.

L. M. FULTON, *Assistant Superintendent of Blast Furnaces*, Dominion Steel and Coal Corporation, Sydney, Nova Scotia.

MERRILL COX, Arthur G. McKee and Company, Cleveland, Ohio.

J. R. HUNT, *Assistant Superintendent of Blast Furnaces*, Tennessee Coal, Iron and Railroad Company, Ensley, Alabama.

B. H. JARRARD, *Steam Engineer*, Tennessee Coal, Iron and Railroad Company, Ensley, Alabama.

W. J. HARPER, *Chief Combustion Engineer*, Republic Steel Corporation, Cleveland, Ohio.

J. S. FULTON, *Special Representative*, Ingersoll-Rand Company, Pittsburgh, Pennsylvania.

R. A. LINDGREN: I think Mr. Fulton has given us a very fine expose of the relationship of gas analyses to carbon rates. There are a few things, though, that I wish he had done, one of which is give us definte information as to how we can get gas analysis accurately

over long periods of time. There is no question that if we know the changes that are taking place from time to time in the gas as it comes off the top of the furnace, we have the drop on the furnace to the extent of six or eight hours in time. But, so far, I have yet to see anyone bring out a method of analyzing gas consistently with sufficient accuracy to be of any value along that line.

In regard to the hydrogen element, it is quite interesting to note that Mr. Fulton brings out the fact that at one plant—I think it is a Nova Scotia plant—they shoot steam into the blast. They are endeavoring to iron out irregularities in the opposite way down in the southern states.

I think some of the next developments should be definitely along the lines Mr. Fulton has pointed toward, and I, for one, would welcome information and equipment that will lead to better and more accurate gas sampling.

L. M. FULTON: The paper by Mr. Fulton contains a brief reference to a furnace blown with steam added to the blast between the blower and the stoves.

About ten years ago we equipped a furnace with modern stoves, but had great difficulty in using the heat. Eventually satisfactory operation was secured by the use of steam in the blast in amounts up to 2½ lb. per thousand cu. ft. of dry air.

The results obtained were:

1. Use of all available stove capacity.
2. Elimination of hanging.
3. Close control of analysis.

An increase in the coke rate was expected but was not observed.

When using large amounts of steam it was possible by shutting off the steam at one cast to increase the silicon in the next cast by 2 per cent or more, but the return to lower silicon was somewhat less rapid.

MERRILL COX: Mr. Fulton has already answered the only question I had, which was this question of compensating for the moisture by varying the amount of wind blown on the furnace, and I would like to ask if any of the others here have ever attempted to do that in any way, or whether any have tried the steam and the hot blast that Mr. Fulton tried up at Dominion, which seems to be the most important feature of this paper—the handling of the moisture in the blast.

J. R. HUNT and **B. H. JARRARD:** Mr. Fulton has very ably discussed the relation between the composition of blast furnace gas and the production of iron in the blast furnace. His findings are based on the results obtained by Brassert, extended to higher carbon rates from the works of Clements on ferro-manganese furnaces. We have been using the formulae and curves developed by Brassert for a number of years in our blast furnace top gas calculations. However, some time ago we became interested in checking Brassert's works, and have since been engaged in obtaining gas analyses and related information. Our data is not complete, but has progressed to the point where we feel certain that definite trends are fairly well established, and we have modified our formulae and curves accordingly. We felt that possibly these modifications were attributable to southern ores and practices, but it is interesting to note that Mr. Fulton has found similar modifications advisable in other localities.

We did not eliminate hydrogen from our calculations, but rather have attempted to correct for a constant volume of hydrogen to eliminate its variable affect on Btu. content and other component gases. When one is dealing with actual data obtained in the field, it is evident that none of the factors can be eliminated. Incidentally, Mr. Fulton has also omitted any reference to the appearance of CH_4 in top gases. He assumes with Brassert that carbon other than that in coke charged into the furnace is balanced by carbon leaving the furnace with the iron and flue dust, thus eliminating the necessity of making further corrections to the top gas composition. Southern practice with relatively high stone charges and carbonaceous ores does not permit this assumption.

Our results indicate that the cubic feet of air per pound of carbon charged in the coke does not increase with increasing coke rates as found by Mr. Fulton, but tend to agree with Brassert that this factor is fairly constant and approximately the same as he reported.

We agree that the Btu. per cu. ft. and per cent by volume of the carbonized gases are not straight line functions of the carbon rates as shown by Brassert. Our results indicate curves, but we are not yet in a position to state the exact values. We also agree concerning the discrepancies in measurement of oxygen supplied, and that reported in terms of standard dry air. We have further found that possibly the greatest irregularity in blast volumes supplied to furnaces is the problem of valve and stove leakage. This condition is aggravated in proportion to the condition and number of stoves serving a single blast furnace.

This phase of blast furnace practice which is under discussion has been given little consideration except by a few who are fortunate enough to have access to records from a large variety of operating conditions. Many months and even years are required to collect and coordinate information of sufficient latitude to formulate conclusive evidence of trends in blast furnace top gas composition. Therefore, we feel that if Mr. Fulton's paper can impress on those responsible the importance of accurate information of the oxygen supplied and actually entering the furnace after leakage is accounted for, the author should be amply repaid for the many hours spent in the preparation of his paper.

W. J. HARPER: I would like to ask Mr. Fulton a question. What is the advantage in the South in reducing the moisture content to 2.85, as compared to the Nova Scotia practice where they have 15 grains?

J. S. FULTON: That is quite a question. The only thing I have to say about the matter of reducing the moisture or increasing the moisture is that it comes down to the same beneficial results. If you have uniform moisture conditions in your blast it doesn't make a bit of difference, mathematically at least, whether it is uniformly wet at a high level, 15½ grains per cu. ft., or at a low level of 3 grains per cu. ft. down in the South, by refrigeration. As far as the operation of the furnace is concerned, as a mathematical operation it doesn't make any difference whether uniformly wet at a high level, or at a low level, just so long as it is uniform. I know there are a lot of people who don't agree with me on that, so we would like to have them talk about it.

W. J. HARPER: It is then your opinion that irrespective of the moisture you can get the same coke practice, whether high or low in moisture content in the blast.

J. S. FULTON: The only thing I can say about that is that the Dominion experience was that when they went from 5 grains of moisture per cu. ft. to 15½ grains of moisture, the coke rate did not increase; the nitrogen decreased almost in direct proportion to the increase in moisture; the CO_2 went up and the CO/CO_2 ratio went down. The coke rate did not increase with the higher moisture and the furnace operation was regular.

W. J. HARPER: You still haven't answered my question. I understand that in the South, for every one grain moisture reduction there is a saving of 48 lb. of coke per ton. If the moisture content in the blast is increased, will there still be a saving of 48 lb. coke per ton of iron for each one grain increase in moisture content?

J. S. FULTON: The best way we can approach an answer to your question is by going back to the fundamental equation of the disassociation of water vapor in the furnace by carbon. For temperatures around 2500 degrees F. the equation is $C+H_2O=CO+H_2$. When this equation is applied to the moisture entering with the blast, it will show that not more than 15 lb. C are required per grain of moisture per cu. ft. or in round figures 18 lb. of coke. This is all of the coke necessary for the disassociation and any amount saved in excess of this, is saved because the operator does not have to over supply coke in anticipation of variable increases in blast moisture.

Therefore, if 48 lb. of coke are saved per grain of moisture removed from the blast, then $48-18=30$ lb. are saved because the blast moisture is uniform.

As a check on this conclusion, L. M. Fulton of Dominion Steel advises that an increase in coke rate was expected but not observed when the moisture in the blast was advanced from .7 to 2.5 lb. of water vapor per 1000 cu. ft. of dry air.

Gayley's original paper on "Dry Blast" in 1905 showed a saving of 112 lb. of coke per grain of moisture removed, but as the furnace practices improved in the following years this saving decreased to less than 15 lb. of coke per grain. With revolving tops, better coke and better charging practice, there was less cream to be skimmed off.

Mr. Lindgren mentions the eight hours that elapse between the time the material enters the furnace and when it enters the hearth, asking if there is any way to determine the continuous gas analyses in order to anticipate changes in the metallurgical reactions of the furnace. While there are different pieces of equipment available to give constant gas analyses, I believe that a simple way to do this would be to install a calorimeter station to determine, constantly, the Btu. per cu. ft. of the top gas.

The Btu. per cu. ft. came from the percentages of CO and H_2. The CO can not change unless the previous "digestion" of the carbon has altered. Presumably the rate of charging carbon has not changed so if CO goes up (as shown by increased Btu.) CO_2 must go down.

The H_2 may vary but only if the moisture entering with the blast or charged with the solids changes.

Then if both the rate of carbon and water charged is constant, any change in Btu. per cu. ft. must indicate a change in the CO/CO_2 ratios from changed furnace reactions between the ore and the CO and C.

Mr. Jarrard makes a point in connection with my assumption that the C in the limestone provides the C necessary for the iron and flue dust, and that this is not true where a large amount of limestone is used per ton this is absolutely correct and shows that in his case, the C in the top gas will always be in excess of the C in the coke. If the C in coke was 2000 lb. and the excess C from limestone was 50 lb., then the gas analyses would be for a 2050 lb. carbon rate per ton, not for a 2000 lb. rate.

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Economics of the

ELECTRIC FURNACE

for Steel Making

By H. E. Phelps

Supt. of Melting Shop

ROTARY ELECTRIC STEEL CO.

DETROIT, MICHIGAN

Presented before A. I. S. E. DETROIT SECTION MEETING, January 14, 1941.

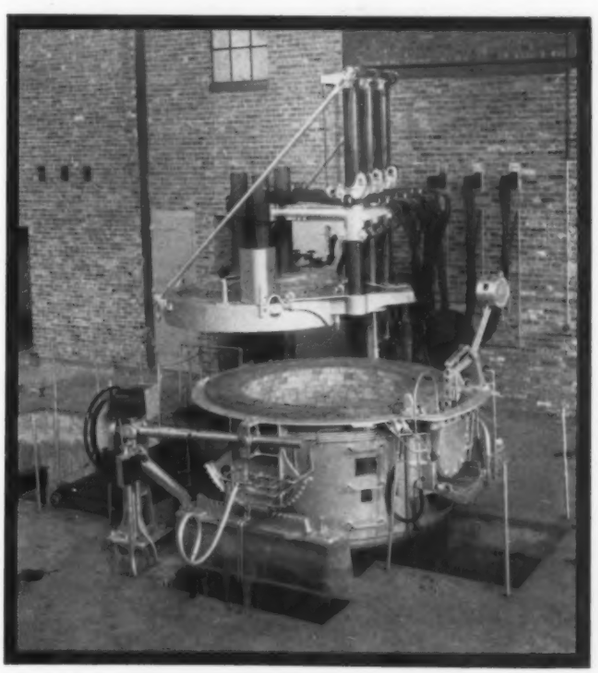
▲ AT the 1940 Convention of the Association of Iron and Steel Engineers, H. F. Walther, of the Steel and Tube Division, Timken Roller Bearing Company, presented a very interesting and complete paper on electric furnace design. For the benefit of those who are not familiar with electric furnace design, it will perhaps suffice to say that after many years of experimentation, furnace makers have settled down to two basic types: the three phase direct arc and the induction furnaces. The induction furnaces are relatively few and of small capacity, and are used chiefly for specialty work. All of the tonnage steels are made in the direct arc furnace and the preponderance of this type of furnace is so great that in speaking of electric furnaces, the direct arc type is generally inferred.

This furnace is essentially a steel shell, usually cylindrical, mounted upon a tilting device and lined with a refractory material. A carbon or graphite electrode at each phase conducts the current into the furnace where it arcs from the electrode to the metallic charge and from the metal back to one of the other electrodes. These electrodes are raised and lowered by means of motor operated winches automatically controlled by means of contact making ammeters. This control is quite sensitive and will regulate to plus or minus 500 amperes when arcing to cold scrap and to plus or minus 100 amperes when arcing to the molten bath, thus giving the operator very close control of temperature.

The furnace we shall consider is 18 ft. in shell diameter, 10 ft. 6 in. in height of side plate and with the fore plate about midway in the side plate. It is powered with a 10,000 kva., 40 degree rise transformer, with five secondary taps; 275, 240, 185, 140, and 105 volts. The three highest taps are connected delta delta and the two lower ones star delta. The normal rated capacity of the furnace is fifty tons and the average heat tapped is 125,000 lb.

Perhaps the greatest single advantage of the electric furnace over other types, lies in its great flexibility. It

The top charge design is particularly adapted for furnaces of the smaller capacities, say under 30 tons.



is the only melting medium in which it is possible to produce the highly oxidized product of the bessemer converter, the refined and partially de-oxidized product of the open hearth and the completely de-oxidized and highly refined electric furnace steels of today, and even improve upon the cupola and air furnace in the production of grey iron and malleable. It is possible to produce each of these metals in successive heats without any change in the furnace and without loss of quality in the product. Like the open hearth, it may be lined either acid or basic.

In our plant it is regular practice to make the three types of steel mentioned. This means an extremely wide range of de-oxidation practices; from slags containing 25 to 30 per cent FeO in the case of some of the bessemer types and rimming steels, down through the range of 10 to 14 per cent FeO in the case of the open hearth alloy steels to the extreme low of .25 per cent FeO or less for aircraft quality electric furnace steels. Thus it can be seen that any steels that can be made in the open hearth or bessemer can be made in the electric furnace, but there are a number of grades that up to the present have been made successfully only in the electric furnace. It can be truly said that the electric furnace is the one and only universal furnace for ferrous melting.

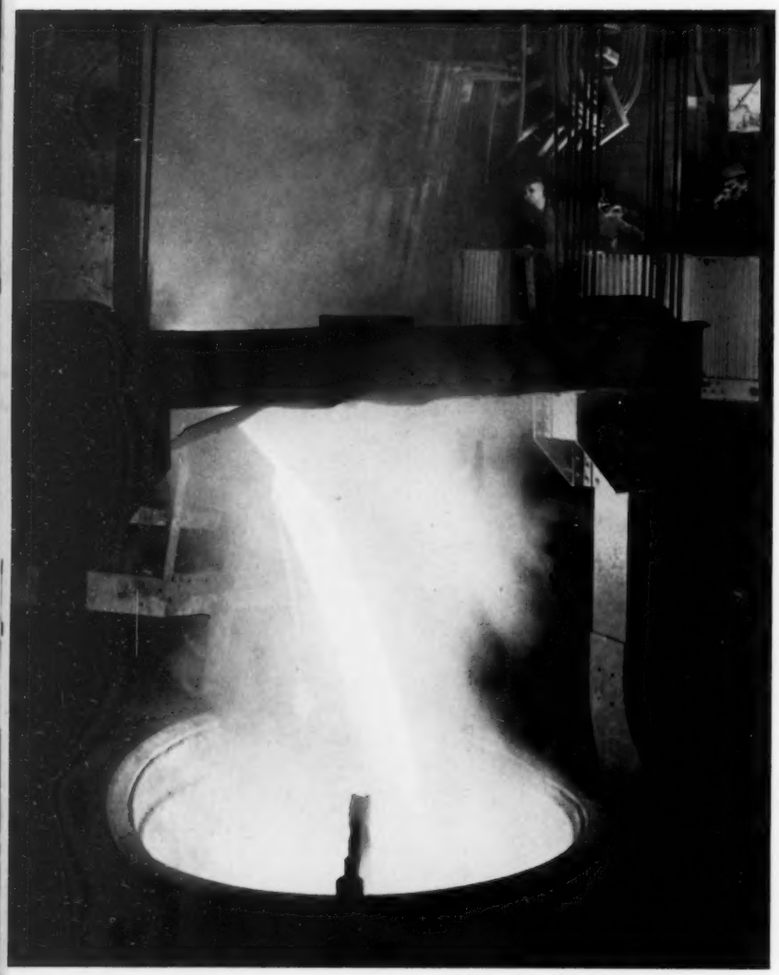
The flexibility of the electric furnace is as outstanding and important from the standpoint of operations as it is from that of product. The sales argument of the tractor salesman to the farmer applies equally well in this case, for the electric furnace like the tractor, does not eat when it is not working. All plants have the problem of part time operation in dull times. When it is necessary to shut this furnace down over week ends, there is no skeleton crew on "gas turn" and no fuel consumed in merely keeping the furnace hot. Instead, all fuel cost ceases immediately after the last heat is tapped. As soon as the ordinary bottom repairs are made, the doors and electrode glands are sealed, and within an hour of tapping, all labor costs have stopped. The only extra cost entailed by a shut down of a day or week is that of a few extra kwh. per ton on the first heat made upon the resumption of operations.

To mention such a thing as furnace practice before a group of melters is just another way of saying that it is a free-for-all and no holds barred, but perhaps it will be safe to outline the common procedures before this group without becoming too greatly involved.

Immediately after having tapped a heat, the furnace is brought back from its tapping position, which is a forward tilt of about 45 degrees, to its extreme backward tilt, which is generally in the neighborhood of 18 degrees, so as to afford the first helper a good view of the bottom. Should there be any holes in the bottom, they are repaired in the same manner as in the open hearth; that is, by rabbling the steel out of the holes or blowing it out with compressed air and then filling in the holes with dolomite or some other refractory. This having been done, the electrodes are raised to their maximum height and charging is begun by means of the conventional open hearth charging machine. A great deal more care must be exercised in placing the scrap to properly charge the electric furnace than is necessary in the open hearth. It is important to get as much scrap as possible in the furnace on the first charge, since the power must be taken off in order to re-charge, whereas all charging may be done in the open hearth with the flame on. For fast and economical melting, the furnace should be charged more heavily opposite the electrodes than elsewhere, otherwise these hot spots will be melted out first, with the result that the power input must be decreased to prevent excessive wear on the furnace lining. All heavy scrap must be placed near the bottom to prevent electrode breakage when the charge slips down, for since the electric furnace melts from the bottom up, any scrap charged above the fore plate line will have to fall into the bath. Limestone charged must be so placed that it will not come under the electrodes, otherwise a broken electrode would result, due to the limestone being a non-conductor. Finally, there is only one charging door, which means that after the furnace has been filled to the fore plate line, any additional scrap must be pushed and rolled back in order to fill the furnace. Incidentally, it is really astounding the amount of scrap a good machine man can get through one door, and when he has finished one wonders how he managed to empty the last box.

The furnace having been charged, the current is switched on at maximum voltage and current, in our

The electric furnace is highly flexible as to both operation and product.



case at 275 volts and 34,000 amperes, the electrodes put on automatic control, and started on their way to the bottom. By the time they have melted down through the scrap to the bottom, they have formed a pool of metal on the bottom and arcing continues to this ever increasing pool until all the charge is melted. Shortly before melting is completed, a preliminary test for carbon and phosphorous is taken so that adjustments can be made and the proper carbon and phosphorous content had by the time the heat is ready to be slagged off. Should the carbon be too high it is reduced by means of mill scale or iron ore as in the open hearth; should it be too low it can be increased by the addition of pig iron or by the simple expedient of switching off the power and immersing the electrodes in the bath for a few minutes. The proper carbon and phosphorous having been obtained, the heat is ready for finishing, and there are a number of ways of doing this:

1. Melting with oxidation, removing the oxidizing slag and making a second and de-oxidized slag; which is the most common practice.

2. Melting with as little oxidation as possible and changing the melt-down slag to de-oxidizing without removal.

3. Melting and finishing either with one or two oxidizing slags and controlling the FeO content.

The second method is used in melting high alloy scrap, such as high speed steel, etc., where the value of the alloys is of paramount importance. It is the slowest of the three practices mentioned, but 100 per cent recovery can be had of any alloy in the scrap. This is important when remelting 14 per cent tungsten scrap for instance, with tungsten selling currently for $2.50 per lb. It is perhaps unfortunate that this practice will also yield 100 per cent recovery of the phosphorous in the scrap, so that assurance must be had that the content of this element is not above the specification. Practices number one and two are in general use in our plant.

The largest arc furnace installed to date is a 100 ton unit, employing six electrodes, and 20,000 kva. transformer capacity.

When the proper carbon and phosphorous have been obtained as mentioned before, the oxidizing melt down slag is removed from the furnace. This is accomplished by back-tilting the furnace slightly and raking the slag off by means of wooden rabbles. By the time this operation is finished, the laboratory will have reported the preliminary analysis and the additions of the various ferro alloys are made to bring the bath within the specification. The lime and fluorspar for the second slag is then spread on the bath by the charging machine.

From this time on to tapping time, the success of the heat depends entirely upon the skill of the melter and the first helper. The method of working the slag to almost complete de-oxidation is purely empirical, for while many attempts have been made to develop a standard slag mix and technique, none has been successful. The methods and materials for making such a slag are perhaps as many and varied as there are plants. The lime may be de-oxidized by carbon in the form of coke breeze or powdered petroleum coke to form a calcium carbide slag, by the addition of some form of silicon to form calcium silicate or by aluminum to make a calcium aluminate slag. Each method has its good points and each its draw-backs, so that it is largely a matter of individual preference. When the slag is de-oxidized, a second preliminary test is sent to the laboratory and upon receipt of the determinations, final adjustments of analysis and temperature are made and the heat tapped.

A log of a typical two slag heat may be of interest:

Tap previous heat	2:48	
Start charge	3:05	
Finish charge	3:25	
Total charge		126,500 lb.
Start slag off	6:00	
Finish slag off	6:10	Slag 10.5 per cent FeO
Add lime for second slag	6:15	
Preliminary test	7:20	Slag .6 per cent FeO
Heat tapped	7:40	Slag .3 per cent FeO
Time tap to tap	4 hr. 52 min.	

Chemistry ordered: C 18/21, Mn 50/60, P 025 max.
Made 19½ 59 016
Ordered: S 040 max., Si 20/30, Cr 15/20.
Made 026 23 20
Ordered: Ni 165/200, Mo 20/30.
Made 177 22

Product: 124,250 lb. in full ingots. Power consumption 523.4 kwh. per gross ton of full ingots.

Illustrative of the flexibility of product are the logs of the following two heats, since these are of the bessemer and open hearth types respectively, in comparison with the orthodox electric furnace types just mentioned.

Tap previous heat	11:08	
Start charge	11:30	
Finish charge	11:50	
Total charge		130,100 lb.
First preliminary	2:30	Slag 21.3 per cent FeO
Second preliminary	2:45	Slag 23.5 per cent FeO
Third preliminary	3:00	Slag 20.2 per cent FeO
Heat tapped	3:21	
Time tap to tap	4 hr. 13 min.	

Chemistry ordered: C 08/13, Mn 60/90
Made: 12 86
Ordered: P 07/09, S 250/300.
Made: 083 294
Product: 124,250 lb. in full ingots. Power 523.5 kwh. per gross ton of full ingots.

This heat is the SAE X1112 screw stock, regularly made in the bessemer. Immediately following this was a heat of SAE 1145 which is one of the open hearth screw stocks. Its log is as follows:

Tap previous heat.....3:21
Start charge.....3:35
Finish charge.....4:05
Total charge..... 130,600 lb.
First preliminary.....6:45 Slag 13.1 per cent FeO
Second preliminary.....7:05 Slag 4.0 per cent FeO
Heat tapped.....7:31
Time tap to tap.....4 hr. 10 min.
Chemistry ordered: C 43/48, Mn 70/100, P 040 max.
Made: 46½ 96 027
Ordered: S 100/150, Si 15/25.
Made: 140 23
Product: 119,925 lb. in full ingots. Power 523.3 kwh. per gross ton of full ingots.

It will be noticed that there was no slag off period in the logs of these two heats. Down to this point, there was no difference between these heats and the first one outlined. But since it was intended to approximate the conditions found in bessemer and open hearth screw stock, a slag off higher in FeO content was desired, and this was obtained with a single slag by controlling the FeO; to finish 20 per cent in the one case and 4 per cent in the other.

I do not mean to infer that all heats are made in the time shown in these logs, but they are typical of the grades mentioned when there are no electrical, mechanical or bottom delays, and are duplicated hundreds of times. I might also add that these logs were chosen at random and the fact that the power consumption in each case is identical is purely coincidental, as the monthly average is somewhat higher.

It may seem that I have wandered far away from my subject, but I think that the flexibility of the electric furnace is just as important economically as the dollars and cents cost of making a heat.

Perhaps the first question one is asked about electric furnace practice is the question, "Is it not terribly expensive?" The answer can only be "yes and no." The fuel cost, that is, the sum of the electrode and power costs, on a fifty ton furnace is about $6.00 per ton. This is the largest single item and is roughly three times that of the open hearth. This is largely compensated for by other savings. First of all comes the melting stock. The usual charge of an open hearth making alloy steel is 50 per cent scrap and 50 per cent pig iron, and the electric furnace always uses 100 per cent scrap. At current quotations this is at once a saving of $1.50 per ton. Refractory costs for the electric are in the neighborhood of twenty cents per ton, which represents a saving of at least a like amount over the open hearth. Maintenance is much lower, and operating labor no higher. Interest on invested capital and property taxes is a big item, for a fifty ton electric furnace costing about $120,000 will make about the same tonnage as a 150 ton open hearth costing many times as much. This saving becomes very evident if one will remember that the electric furnace is a complete unit, requiring no gas producers, coke ovens or oil tanks and pumps to serve it. Interest on invested capital, property taxes and maintenance of this auxiliary equipment must also be taken into consideration.

Recovery of alloys is an important item. Under any of the practices mentioned, the residual alloys will be higher with a given carbon content in the electric than in the open hearth. For example, it is routine for us to melt vanadium scrap with the two slag practice and obtain 50 per cent recovery. At the present price of $2.70 per lb. of vanadium, this is no small item. Chipping costs will invariably be much lower on electric furnace steel. Comparison of our chipping costs with some open hearth plants making comparable grades of steel show nearly $2.00 per ton in our favor. It is quite safe to say that generally there will be an increase in the overall yield of electric furnace steel amounting to about 5 per cent. Taking all these factors into consideration, it is quite evident that profits are made on the cost of the steel to the shipping department and not on the cost of the metal in the ladle.

It should be remembered that this comparison, like all others heretofore, has been made between a small tonnage of electric furnace steel and tremendous tonnages of other kinds. The savings possible in supervision, labor and maintenance costs in an electric furnace shop having the capacity of the large open hearths with from ten to twenty furnaces, is somewhat a challenge to one's imagination.

A number of these 60 ton units, provided with 12,500 kva. transformer capacity, have been installed recently.

With the immense increase in electric furnace capacity since the start of the war, it may be that there will be an answer to some of these thoughts, and that the open hearth will find that it really has a competitor.

DISCUSSION

PRESENTED BY

A. J. F. MacQUEEN, *Superintendent of Maintenance*, Rotary Electric Steel Company, Detroit, Michigan.

L. R. MILBURN, *Electrical Engineer*, Great Lakes Steel Corporation, Ecorse, Michigan.

H. E. PHELPS, *Superintendent of Melting Shop*, Rotary Electric Steel Company, Detroit, Michigan.

A. B. OATMAN, *District Manager*, Electrode Division, National Carbon Company, Inc., Detroit, Michigan.

I. A. ROHRIG, Detroit Edison Company, Detroit, Michigan.

L. W. CLARK, Detroit Edison Company, Detroit, Michigan.

M. J. WOLGEMUTH, *Engineering Supervisor*, Westinghouse Electric and Manufacturing Company, Detroit, Michigan.

N. D. DEVLIN, *Vice-President, Charge of Operations*, Rotary Electric Steel Company, Detroit, Michigan.

W. B. HURLEY, Detroit Edison Company, Detroit, Michigan.

A. J. F. MACQUEEN: There are a lot of things about electric furnaces that are interesting. The economics of the thing, is after all, the final answer. Incidentally, there are a lot of other interesting angles; in the matter of electrodes, for instance. The electrodes in an electric furnace are a big item. Then there is the matter of electrical equipment involved and the furnace design. Another thing about them, being electric furnaces, they use electric power and the power company gets something. And there are some interesting angles in connection with the power loads with electric furnaces.

L. R. MILBURN: I would like to ask how you dispose of the slag.

H. E. PHELPS: We simply haul it out to the dump.

A. B. OATMAN: I have tried to check Mr. Phelps' figures here a little bit, and according to what the speaker has set for power cost and charge cost, he must put his electrode costs pretty high if he is going to get $6.00 a ton. However, checking electrode costs given very roughly it still leaves the electrode costs high, it seems to me, in proportion to power consumption of 523 kwh., at less than a cent a kwh. However, I am not prepared to go into the subject of electrode costs, or that of electric furnace operation, because it is a subject governed by too many factors especially in connection with alloy steels.

In 1918, the largest graphite electrode made was 12 in. in diameter, and it was thought that the maximum of electrode size was reached at that time. In fact, there was much difficulty in 1916 in making 12 in. electrodes. Our maximum recovery from our furnaces was about 50 per cent. I don't know what the maximum recovery is now, but it is over 90 per cent.

Electric furnace tonnage has increased tremendously —that is, the average electric furnace tonnage—has increased from 1918 up to the present time. If I am right, at the end of 1918, in Chicago, Illinois, there were two or three fifteen ton furnaces, and three six ton furnaces, which were the biggest furnaces at that time. Electric furnaces have kept increasing in capacity both tonnage and electrically until now the usual big furnace is a 60 ton unit. The biggest unit today is a 100 ton unit, at Timken.

Those furnaces have required tremendous increases in transformer capacity, and consequently, a necessary increase in electrode size. The electrode manufacturers —and I am speaking of graphite electrode manufacturers because the carbon electrode has become almost static as far as the steel furnaces are concerned—have had to work hard to provide the proper electrodes. There is only one electric steel furnace which has been installed recently to use a carbon electrode. This increase in size of the electric steel furnace has called for an increase in size of electrodes, and we have gone successively from 14 in. electrodes to 16 in. electrodes to 18 in., and we are now making 20 in. graphite electrodes.

I was telling Mr. Phelps before the meeting that there was a time when people were of the opinion that the 18 in. was absolutely the largest electrode we could make with the basic materials we had, which is petroleum coke. We are making 20 in. electrodes now.

The electrode consumption and cost per lb., however, has been constantly dropping off. When Timken was making pretty good tonnages of alloy steel in a battery of five six-ton furnaces, their electrode consumption was well up in the range of 20 lb. per ton in a test run of 12 in. graphite, and the best electrode consumption was about 18½ to 19, including breakage in installing and general oxidation. The general consumption of larger graphite electrodes is now around 12 lb. per ton.

Material reduction in electrode consumption is due in a large extent to progress made by electrode manufacturing and due also in a large extent to the ability of steel operators. They are considerably better now than they were twenty years ago. Some of you will bear me out. I could go into this thing in a lot of detail; I don't want to do it.

It will be only a short time before you see bigger electric furnace capacities than the 60-ton in three electrode furnaces, because the 100-ton at Timken is a six-electrode unit. My own management might quarrel with me when I say that bigger than 20 in. graphite electrodes will be made. They said that bigger than 18 in. electrodes couldn't be made, too. We had made semi-graphite electrodes up to as big as 40 in. They are not in standard use now, but some slightly smaller are. I think that only means that petroleum coke base

electrodes can and will be made larger than 20 in., and I think those electrodes will be of as high a quality as 20 in. are now.

I don't think that the electric furnace operator of the near future has to worry very much as to getting an electrode that will take care of all of his electrical and mechanical needs.

H. E. PHELPS: I would like to break down that figure of costs I have given. Electrode cost is about $1.50 per ton.

L. R. MILBURN: What percentage of electrode cost do you figure as breakage and wastage due to ends, or do you have that any more?

H. E. PHELPS: We don't have the wastage on ends that was customary years ago. It is a rare thing not to consume the entire electrode and we keep no record of percentage of breakage. The figure of 12 lb. per ton includes all breakage. Should a certain car of electrodes show some breakage or unusually high consumption, I talk adjustment with the electrode manufacturer.

L. R. MILBURN: Do you have some breakage in your plant?

H. E. PHELPS: Very seldom. The amount is so small that we do not try to keep a separate cost on it. Electrodes are made with a female thread on each end, and occasionally this cavity is broken off. Should it be on the top joint of the column, there is no loss, for we return the joint to the electrode makers who very graciously re-thread it and return it to us. But to lose a whole column is very rare indeed, and when this does happen, the broken electrode has a salvage value as a recarburizer. Our loss from breakage is therefore negligible.

A. B. OATMAN: This gentleman spoke about the stub end loss. I don't know what your experience is with electrodes, whether from experience or hearsay. When electrodes were first made, they were carbon electrodes and had no joints. This meant a big butt loss. Later a male and female joint was developed. This was a tremendous step forward but still left a lot to be desired as far as mechanical strength was concerned. A nipple joint was later made, and that further cut down on the stub loss. There has been a tremendous increase in manufacturing skill, and with the nipples the strength was increased, so that as Mr. Phelps said, it is very unusual to have even a small particle of that nipple lost. With stainless steel any amount—when I say "any amount," I mean a very small amount—of carbon droppage into the metal is fatal. But, the technique improved for the making of joints and machining joints, and the coned nipple has cut down that mechanical loss of electrodes, so that it is less than 1 per cent of the total electrode consumption.

I. A. ROHRIG: What is the approximate weight of the standard 20 in. electrodes?

H. E. PHELPS: They are six-foot joints, and they average 1250 lb. It takes three joints in each phase to reach the bath.

L. W. CLARK: While the paper deals primarily with the economics and costs of electric steel making, my comments will, of necessity, deal with the electrical characteristics of the furnace and its effects upon the power supply system.

The arc furnace usually presents a desirable type of load from the standpoint of the power company if it can be served at such a location and in such a manner that the inherent load fluctuations of the furnace do not set up objectionable voltage fluctuations or lamp flickers at lighting customers. With a large furnace of this type there are not many such locations available on the ordinary power company system. When it is realized that a 10,000 or 12,000-kva. furnace must be served at a location where the short circuit kva. is in the order of 1,000,000 kva., the scracity of suitable locations can be better appreciated.

While it is true that large furnaces operate proportionately much smoother than do the small 1000 and 2000-kva. installations, the actual magnitude of the fluctuations are nevertheless great. A 1000-kva. furnace may have three-phase fluctuations as high as two or three times its rating as compared with fluctuations of only about equal to the rating in the case of a 10,000-kva. furnace. These are fluctuations in single steps such as will cause lamp flickers and are not to be confused with gradual load changes which may build up to values as high as 30,000 kva. for several seconds in the case of a 10,000-kva. furnace. A record covering several years' operation shows that the load reaches 30,000 kva. for some reason or other on the average about once a week and holds this value for a period of from 10 to 60 sec.

In view of this magnitude of both instantaneous and gradual changes in primary load current, I was particularly interested in Mr. Phelps' statement regarding close regulation of secondary current obtainable with modern, automatic electrode control—a plus or minus 500 amperes during the melt-down and plus or minus 100 amperes during the refining period. As the circuit in question is a 30,000-ampere circuit, this represents a regulation of less than 2 per cent plus or minus. This certainly is an excellent job of regulation which I believe refers to an average regulation over a period of time rather than possible instantaneous load changes that usually do not hold within such ideal limits.

H. E. PHELPS: I might say in rebuttal to Mr. Clark—a furnace man never worries about the surges when the scrap falls against the electrodes—he lets the power company worry about that. When we speak of regulation we mean the steady load.

A. J. F. MACQUEEN: I would like to ask Mr. Clark whether he has any idea if two or three or four of these furnaces in one plant would help to smooth out the power load, and just how it would affect it.

L. W. CLARK: Our experience has been that with two furnaces it is not much worse than having one as far as these disturbances are concerned. We had to step up our relaying a little bit, but from the standpoint of causing flickering or anything of that nature, I don't believe two or three or four of the same size is much worse than the first one. You very seldom get a condition where you will pile up on the load and get one of these big services that pile up to cause the lights to flicker a little bit.

M. J. WOHLGEMUTH: I don't know much about

the electric furnace operation, but I am very much interested in what Mr. Phelps told you of the operating cost. I see that operating costs have gone down. I remember not very long ago they were up to 600 kwh. per ton. As far as electrical equipment for furnaces, it hasn't shown very much change over a period of years. We are still using a regulator and transformer and circuit breaker. But, as Mr. Clark says, the power swings are rather heavy, and I think it is a credit to the manufacturers of the transformers that they can take it.

Since the advent of the larger electrodes it has meant working these furnaces rather hard. That puts a greater strain on the electrical system.

H. E. PHELPS: I rise in rebuttal again. You mentioned something about the power consumption as around 600 kw., but that was around five years ago when for the reason of crane capacity we were undercharging the furnace. That makes a difference. As I mentioned in the paper, the figure of 523 is not an average; it is purely coincidental. The average per month is between 550 and 560.

L. R. MILBURN: Have you reached a limit in your economy of power? Is there anything more you can do? In other words, would a larger transformer bring that down any?

H. E. PHELPS: I believe it would. In my experience, every increase to a larger transformer and a larger furnace, has given us lower power cost. A ten ton furnace will probably average 750 kwh. per ton, a thirty ton about 630 to 640 and a hundred ton about 540.

There are other factors than size that can influence power consumption. One of them is the selection of scrap. It is possible to get a consumption of 25 to 30 kwh. more per ton with a poor grade of scrap. Flat heavy section scrap that packs well but will not weld into one mass is the most rapid melting. Compressed bundles are considered good scrap for the open hearth but are very poor for the electric. They tend to pile up in the furnace and will not fall in under the electrodes and a charge of this type will take hours longer to melt than well cut flat plate.

A. J. F. MACQUEEN: Would you mind telling us something of the methods of charging a furnace with a removable top, and how it ties in with furnace size?

H. E. PHELPS: I would say that it is largely a matter of preference. I prefer the machine charged furnace in the larger sizes. For the smaller furnaces, I think the top charge is the only logical solution of the problem. But when considering furnaces of 30 tons or more, the top-charge school is over-looking one fact, and that is that the charging machine is used for a good many other things than putting scrap into the furnace. In fact, that is only a small part of its work. Putting the second slag on is a point. It will take three helpers at least fifteen minutes to do it by hand, and it will not be as well done as it is when put on by the machine, which takes about three minutes. Burnt lime is quite light and it is difficult to throw a shovelful across the furnace with the result that the inaccessible parts of the bath have little if any covering while the more easily accessible parts are covered too heavily. The charging machine covers the entire bath uniformly.

Another preference that I have for the charging machine is that it permits of selective placing of the scrap in the furnace. Longer scrap such as mill crops can be used than would be possible if the scrap were dropped into the furnace from the top. We take mill scrap up to 6 ft. length and use a good percentage of No. 1 heavy melting scrap which has an allowable length of 5 ft. We charge all of our scrap moulds whole. They would have to be broken if charged otherwise.

N. D. DEVLIN: I would like to ask how you would make a heat of stainless on a top-charged furnace.

H. E. PHELPS: I have asked that question a good many times but no one has yet given me a good answer. To make a 30 ton heat of 18-8 stainless steel requires between 16,000 and 17,000 lb. of ferro chrome. This is usually heated before adding, and added after the reducing slag is put on. To shovel it in by hand is a tremendous job, which in one plant that I know of requires a crew of laborers who do little or nothing else. With a charging machine there is no problem. I certainly should not want to drop such an amount of chrome, equivalent to 25 per cent of the weight of the heat, into the bath from the top after I had the heat shaped up. But, some people like them and as I said before, it is a matter of personal preference.

N. D. DEVLIN: What about the size and capacity on the economic end of it?

H. E. PHELPS: I think it is axiomatic, the larger the furnace, the lower the cost, and the lower power consumption is. I think the biggest difference is under 30 tons; going up to 30 tons or higher, there is not as big a change in cost as from 10 to 30 tons. I don't think a furnace under 30 tons could compete with an open hearth, but it is entirely feasible with a 50 ton. We have been doing it in the last six or seven years, competing even with the bessemer.

A. J. F. MACQUEEN: I take it then that to get economic operation of electric furnaces, that is to continue to get the cost down, that it is necessary for the furnace designer and the electrode man and electrical man to build larger and larger furnaces.

H. E. PHELPS: There might be an optimum there. No one has had a three-electrode 100 ton furnace yet, but I could imagine the cost would be lower than on a 50 ton. Because, after all, a considerable time of steel making is spent in getting an analysis. It takes no longer for a preliminary analysis on a 100 ton heat than for a 50 ton, so half of the laboratory delay is saved. A 50 ton heat will take as much of the melter's time as a 100 ton. For example, one melter could take care of three or four furnaces, and it would make no difference if they were of 30, 50 or 100 tons capacity. There would no doubt be a saving in power consumption in the larger furnaces and supervision, maintenance and refractory costs would certainly be lower.

A. B. OATMAN: How much bigger shell diameter do you have to have on a 100 ton 3 phase furnace?

H. E. PHELPS: I have never figured it out. The 60 ton furnaces are 19 ft. and our 50 ton is 18 ft. I am told that some of the recent 19 ft. furnaces are being given a charge of from 150,000 to 160,000 lb., so while they

are called 60 ton furnaces, they are really producing 75 to 80 net tons.

W. B. HURLEY: Summing up the question, as I interpreted it, it showed the handicap of about $4.00 per ton on your electrode and current cost, as compared with open hearth costs, and I think the final cost totalled out about the same, or was there any actual difference between the two costs?

H. E. PHELPS: I honestly think it does not total out the same, and I think if comparable tonnages were considered the difference would be in favor of the electric furnace. Of course I do not have the confidential costs of the open hearth plants, but I do know of cases of plants having both types, that it was more economical to make certain open hearth orders on the electric furnace because of the saving in alloys.

W. B. HURLEY: I think it is true on your tonnage; your power cost would drop $1.00 to $1.50 on the bigger furnace load because you would get a higher load factor and a step-down into the lower steps of demand, which might reduce your cost per ton. It might drop $1.00 to $1.50. I am talking about a plant which might have anywhere from 50,000 to 100,000 kw. demand.

H. E. PHELPS: I think it is possible in a large plant to cut your power costs as much as 25 per cent with large consumption. I do know that in the Canton, Ohio, district, their rates are quite a bit lower than ours, and it is due primarily to their large consumption.

We operated for a number of years with just the one 50 ton furnace, and about a year ago we started a 30 ton. With the two furnaces we are holding a combined demand to 15,000 kva. If you had three, perhaps you could hold it to 20,000, and so on. With each demand, and the energy consumption going up, it would give you a better rate.

L. R. MILBURN: Mr. Phelps, a few weeks ago I read an article about the increased addition of nickel into the scrap steel. Is there any way you can control that in your electric furnace, or do you still add nickel every time you melt that steel down?

H. E. PHELPS: We generally add it, but we wish sometimes that we could take it out. There isn't very much you can do about residual nickel in the scrap.

Labeka Discussion

(*Continued from page 32*)

results. There is no question in my mind but that controlled cooling would be a step in the right direction.

W. B. FARNSWORTH: There are a lot of points brought out in Mr. Labeka's paper on which I would like to get some information. Especially in our mill and allied mills, the question of dog bites comes up. I think all the men are familiar with dog bites, as we call them. I know you can chase some of them back to cracked moulds, and different factors there, but I also happen to know that the perfect ingots we have chipped before putting in the pits show up in the big mill as dog bites.

I suggested to one of our blooming mill men, why not take the ingots, have them soak for an hour, reverse and turn them around, and run about 12 or 14 ingots. It seemed, when we did that, those dog bites disappeared.

I wonder if some of those things don't play an important part in cutting down the reconditioning costs. I know it costs us plenty of money to get the cracks out of the slabs and bars. The chipping foreman says, "We don't worry about those; we can see those." Nevertheless, I wonder if anybody can give any information on how to prevent dog bites in most of the ingots. You might call them big ingot cracks. That is the way they show up in the big blooming mill. I know there are a lot of blooming mill men around here who will say that is due to open hearth practice.

R. I. GUMAER: Mr. Labeka has brought out the importance of short track time, particularly on thin-skinned ingots. I wonder if he could tell us what would be considered a good time range for ingots of that type.

He has also brought out the importance of heating time. There, again, I would like to know what would be considered too fast time for steel that is charged at possibly 1400.

C. L. LABEKA: Track time is a factor that depends to a great extent upon the stripping facilities and distance between the open-hearth and the soaking pits. Our average transit time on thin-skinned, capped ingots is 40 minutes. We would like to get these ingots into the pits faster than that. What we do not like is a heat of steel that does not show color.

When we have ingots that appear to be thin-skinned, the open-hearth observer sends word to the blooming mill observer and blooming mill foreman. These ingots are then pushed ahead of everything else into the soaking pits. It is possible at the time that we may not have the soaking pit space to put them in. When the pits are available, we put those ingots into the pits first. We try to cool the pits down so that the temperature of the pits is not high.

In answer to your second question we have not arrived at any heating time expressed in degrees per hour. The recent installation of the automatically controlled pits, however, will give us excellent equipment to study this point. We do attempt to cool the pits to the color of the incoming ingots and then heat slowly with less than full gas with frequent reversals. This has certainly decreased the number and severity of bloom cracks.

SHARON
STEEL CORPORATION

By T. J. ESS *with personnel photographs by* J. R. SCOTT

▲ THE Sharon Steel Corporation, with plants at Lowellville, Ohio, and Sharon, Pennsylvania, forms a splendid example of the small independent producer, who, through capable and far-sighted management, has maintained an efficiency of operation enabling it to compete successfully with the larger, more completely integrated producers.

The Lowellville Works, located on a site of about 200 acres on the south bank of the Mahoning River, was formerly the Youngstown Iron and Steel Company, a pioneer of the industry in the Mahoning valley. The open hearth and blooming mill at this plant were installed in 1903. This company was merged into the Sharon Steel Hoop Company in 1917. Installation of an electric furnace in this plant has recently been completed.

Construction of the Sharon Works was started in 1900 and consisted of one 8 in. and one 9 in. mill, both of hand looping type. In 1905 a 10 in. mill was built, this being a semi-continuous type, and in 1928 a continuous high-speed hot strip mill was installed for the production of strip up to and including 22 in. in width, thereby giving the company a width range from ¼ in. to 22 in. inclusive. At the same time a most modern cold rolling plant was constructed with a capacity of approximately 5000 tons per month of high finished cold rolled strip. In 1902 construction was started on an open hearth plant as well as a blooming mill and billet and slabbing mills, which units were placed in production in 1903, and supplied the semi-finished steel to the Sharon finishing mills until the company purchased the Youngstown Iron and Steel Company in 1917. The open hearth, blooming mill and billet and slabbing mills at the Sharon plant were abandoned in 1920, as by that time the Lowellville Works' capacity had been increased sufficiently to care for the entire Sharon requirement of semi-finished steel.

In 1936, the Sharon Steel Hoop Company reorganized under the name of the Sharon Steel Corporation. The corporation now has an annual capacity of 155,000 gross tons of pig iron, 500,000 gross tons of ingots, and 356,000 gross tons of finished hot rolled material. Products include pig iron, ingots, billets, slabs, sheet bar, hot and cold rolled strip, hot and cold rolled sheets, light plates, flat bars, hot and cold rolled stainless and alloy strip, hoops, bands, and coated products.

The company also controls the Niles Rolling Mill Company, at Niles, Ohio, consisting of hot sheet mills, annealing and normalizing furnaces, picklers, galvanizing pots, etc.

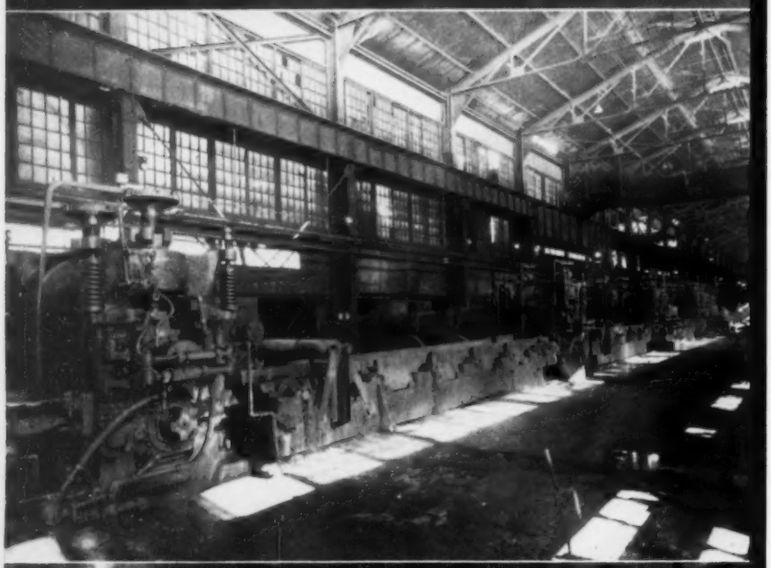
J. H. CARTER

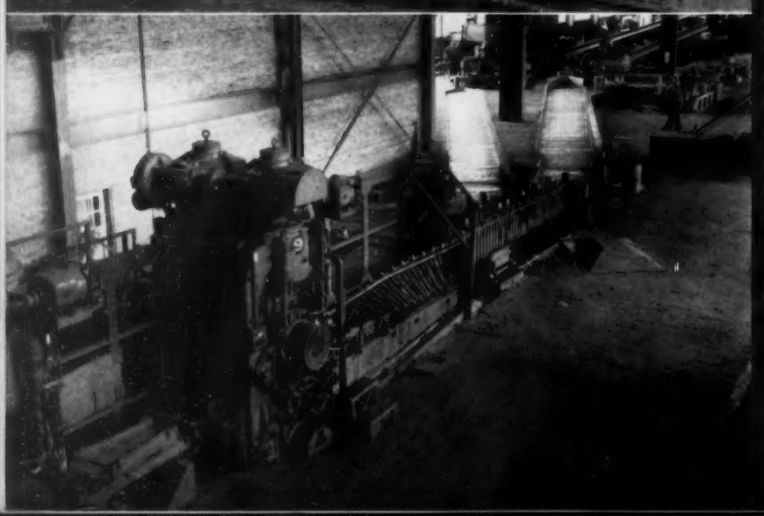
VICE-PRESIDENT IN CHARGE OF OPERATIONS

LOWELLVILLE PLANT

The Mary Furnace, the oldest blast furnace in the Mahoning valley, was rebuilt in 1930 to the following lines:

Hearth diameter	13 ft. 6 in.
Bosh diameter	19 ft. 0 in.
Stockline diameter	13 ft. 6 in.
Height of crucible	8 ft. 9 in.
Height of bosh	11 ft. 6 in.
Height of straight section	8 ft. 0 in.
Height of inwall section	38 ft. 9 in.
Height of stockline section	14 ft. 0 in.
Total height, hearth to top platform	81 ft. 0 in.
Height, hearth to cindernotch	4 ft. 0 in.
Height, hearth to tuyeres	7 ft. 0 in.
Volume, hearth to stockline	12,271 cu. ft.
Bosh angle	76 degrees 33 min. 5 sec.
Inwall slope in 12 in.	0.84375 in.





The brick lining ranges from 2 ft. 3 in. to 3 ft. 0 in. in thickness, and cooling plates are provided throughout the bosh section.

The company has joint ownership in ore properties from which a portion of its requirements are supplied; the balance is purchased in the open market. Arriving at the plant in hopper cars, the ore is stocked from trestles, being subsequently reloaded by steam crane and clam shell bucket, for movement to the stock bins. Ore buggies in the stock house are moved by tractors. The double skip hoist is driven by a steam engine, while a steam cylinder operates the bell hoist. A single bell, 10 ft. in diameter, seals the furnace top. As no coking facilities are included in the plant, all coke is purchased, being unloaded directly into the stock bins from hopper cars.

Blast for the furnace is supplied from three blowing engines, each with a capacity of 40,000 cu. ft. at 13½ lb. per sq. in. pressure. The blast is heated in five stoves, four of which are 80 ft. x 18 ft., and one of 80 ft. x 20 ft.

The furnace operates at a rate of about 450 gross tons of basic iron per day, with a coke rate of about 1720 lb. per ton. With full steel plant operation, blast furnace capacity is inadequate to supply the iron required by the steel plant. A granulation pit provides for slag disposal.

The 34 in. blooming mill *(top)* and the 21 in. continuous sheet bar and billet mill *(immediately below)* at Lowellville provide break-down facilities for the ingots, part of which is re-rolled on the 24 in. strip mill at Sharon, shown in the two lower views.

Blast furnace gas, which is cleaned by passage through a dust catcher and a wet tower type washer, is consumed in the stoves and in the boilerhouse.

One single strand pig casting machine is installed, although most of the iron is taken to the open hearth as hot metal, in 90,000 lb. open type ladles.

The steel plant is located about one mile west of the blast furnace. Six basic open hearth furnaces have been enlarged so as to tap heats of 150 gross tons. These furnaces, built with sloping back-walls, are 66 ft. 6 in. overall length, with bath line dimensions of about 36 ft. 3 in. x 14 ft. 3 in. Regenerator chambers are 16 ft. long x 14 ft. 1 in. and 7 ft. 1 in. wide, and contain about 10 ft. depth of checkerwork of a special design employing a beveled brick shape. The furnaces are completely insulated below the charging floor and on the port side and end walls. Fuel oil is atomized by steam which is highly superheated by passage through piping inside of the regenerator chambers. A shop average of about 27 gal. of oil per gross ton of ingots is maintained. All of the furnaces are equipped with automatic pressure controls and with roof temperature indicators. One furnace also has automatic fuel-air ratio control.

Furnace charges average about 22.5 per cent hot metal, 14 per cent cold pig, and 63.5 per cent scrap, with 8 per cent burnt lime. A typical monthly production rate is 11.3 hr. per heat (tap to tap), or 13.3 gross tons per hr. A wide variety of product is made, ranging from low carbon rimming steels to high carbons, SAE grades, and high silicon steel. Over half of the production is of special grades.

Handling equipment in the open hearth includes two high type floor chargers, one 60 ton hot metal crane, and two 150 ton ladle cranes.

Steel is poured into 21 in. x 23 in. and 23 in. x 25 in. ingot moulds, which have been previously dipped in tar. Moulds are of big-end-up and big-end-down types,

according to the grade of product. About 28 per cent of the steel produced is hot-topped.

A recent addition to the production capacity of this plant is an electric arc furnace, located in an extension at the east end of the open hearth building. This unit is 14 ft. 3 in. in diameter, and taps heats of 20–22 gross gross tons. Three 14 in. electrodes are employed, and power is furnished from a three-phase 6000 kw. transformer of 22,000 primary voltage. Taps are provided so as to give secondary voltages (with delta connections) of 250, 235, 220, 205 and 190 with full capacity, and 175 and 160 with reduced capacity. With Y-connections, secondary voltages of 144, 135, 127, 118, 110 and 92, with reduced capacity, are available. This furnace produces the various "stainless" grades, for which it was previously necessary to purchase the ingots.

After solidification and stripping, ingots are charged into the soaking pits, of which there are six blocks of four holes each. The holes in five rows are 6 ft. wide x 10 ft. long, and 6 ft. wide x 16 ft. long in the sixth row. The pits are of the conventional regenerative type, fired with producer gas supplied from five automatic and four hand-poked producers. There is also a preheating pit capable of holding 24 ingots, fired with natural gas. This pit may be used for slowly preheating ingots of special grades, such as stainless, high carbon, or high silicon, up to temperatures of about 1500 degrees F. The pit may also be used for retarded cooling of ingots of special grades.

After drawing, ingots are brought to the blooming mill by a semi-automatic ingot buggy. The blooming mill is a two-high 34 in. reversing unit, driven by a 3500 hp., 700 volt d-c. motor at speeds up to 120 rpm. Power is supplied to this motor from a 1200 kw. 700 volt flywheel set driven at 353 rpm. by a 2750 hp., 2200 volt motor.

Following the mill at a distance of about 171 ft. is a shear, and in the same line, 135 ft. farther, is a 21 in. continuous sheet bar and billet mill. This mill is made up as follows:

Stand	Distance from preceding stand, ft.	Roll rpm.
Edger	..	..
No. 1 stand	6	18.4
No. 2 stand	8	25.45
Edger	28	..
No. 3 stand	6	40.0
No. 4 stand	34	52.0
No. 5 stand	40	72.0

The five main stands, equipped with oil film roll neck bearings, are driven through gearing and line shaft by a

J. H. MORRISON *(top)*
GENERAL WORKS MANAGER

W. W. SCHOFIELD *(middle)*
WORKS MANAGER, LOWELLVILLE

W. S. JACKSON *(bottom)*
WORKS MANAGER, SHARON

H. P. REES

ASSISTANT WORKS MANAGER, LOWELLVILLE

•

L. L. WILSON

ASSISTANT WORKS MANAGER, SHARON

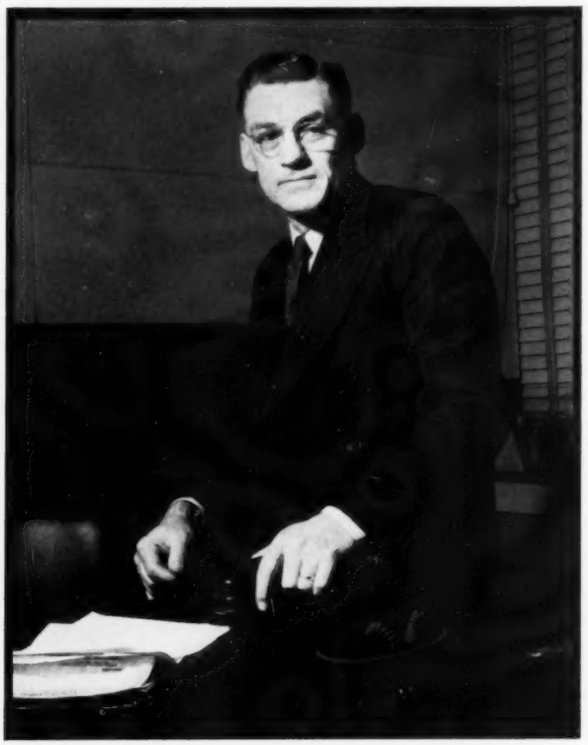
•

STANLEY GRAND-GIRARD

SUPERINTENDENT ELECTRICAL AND MECHANICAL DEPARTMENTS

4000 hp., 2200 volt, 360 rpm. synchronous motor. Each of the 18 in. edgers is driven by a 250 hp., 230 volt, 400–1600 rpm. d-c. motor. Auxiliary 250 volt d-c. power for the steel plant is supplied by two 1000 kw. motor generator sets and one 750 kw. set. The mill runs at a delivery speed of 395 ft. per min. Descaling sprays along the mill are supplied from a 650 gal. per min., 1000 lb. centrifugal pump.

Product from the mill passes on through a 42 sq. in. steam driven hot flying shear, over a hot bed, and on to a piler. This mill combination operates at a rate of 64 tons per hr. Product includes sheet bar in gauges from .225 in. up, and in widths up to 20 in.; billets, 1¾ and 2 in. square; and flats 2–4 in. thick in widths up to 22 in. About half of the product does not require surface preparation. Of the remainder, about 40 per cent is chipped and 60 per cent hand scarfed. The chipping and scarfing building is 264 ft. long x 62 ft. wide. Bottled



acetylene is used for scarfing, and oxygen is piped throughout the plant from an adjacent manufacturing plant.

Practically all of the steel produced in the Lowellville Works is shipped in semi-finished form to the Sharon plant and the Niles Rolling Mill Company, a subsidiary, for further rolling and processing.

With the exception of one 100 kw. d-c. generator located at the blast furnace, all power for the Lowellville plant is purchased. Incoming transformers include two 4500 kva. banks and one 5000 kva. bank, 22000/2200 volts. Only two banks are used, with the third serving as a spare. The plant makes up a 2200 volt connected load of 8450 kva., and sets up a 15 min. demand of 6800 kva. In addition, there is the 6000 kva. bank of transformers supplying the electric furnace.

Steam for plant usage is supplied from two boiler houses. At the blast furnace there are six boilers total-

In the hot strip mill the roughing train is driven by a single 4500 hp. motor, through line shaft and gears.

ing 2914 hp. in capacity. They operate at 125 lb. per sq. in. pressure, and are fired with blast furnace gas, with hand coal firing as an auxiliary. The steam produced is used by the furnace blowing engines. At the steel plant, five 150 lb. boilers, totaling 1402 hp., supply all the steam usage, including oil atomization, gas producers, flying shear, etc.

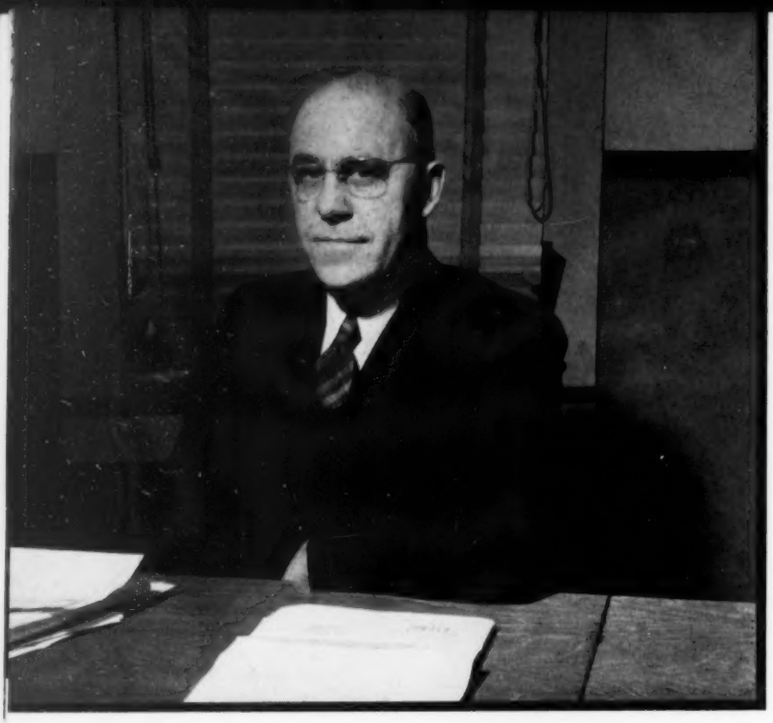
Plant service water is pumped from the Mahoning River. Four centrifugal pumps are provided, one of 9250 gal. per min., two of 5200 gal. per min. each, and one of 2500 gal. per min., all motor driven. Drinking water is supplied from drilled wells.

SHARON PLANT

The Sharon plant consists essentially of four hot strip mills, with a complete layout of cold mills and finishing equipment. A hot rolled capacity of about 400,000 net tons per year is available, while the cold mills represent a capacity of about 60,000 net tons per year. Product includes hot rolled strip $\frac{3}{8}$ in. to 22 in. wide in gauges up to .375 in., and cold rolled strip $\frac{1}{4}$ in. to 22 in. wide in gauges up to .25 in., as well as galvanized material, tin and terne coated material, enamel iron, and stainless

MILL DATA

Stand	Characteristics	Roll length, in.	Roll diameter, in.		Motor			
			Work rolls	Back-up rolls	Hp.	Volts	Rpm.	Type
Continuous Hot Strip Mill								
No. 1 rougher	Two-high	24	19½	....				
No. 2 rougher	Two-high	24	17½	....				
No. 3 rougher	Two-high	24	17¾	....	4500	600	150/450	d-c.
No. 4 rougher	Two-high	24	18	....				
No. 5 rougher	Two-high	24	18½	....				
No. 6 finisher	Four-high	24	15¼	32	1000	600	103.5/253	d-c.
No. 7 finisher	Four-high	24	15¼	32	1000	600	137/326	d-c.
No. 8 finisher	Four-high	24	15¼	32	1250	600	213/500	d-c.
No. 9 finisher	Four-high	24	15¼	32	1250	600	312.5/625	d-c.
Cold Mills								
Tandem mill	Cluster	26	10½	21	200	230	300/900	d-c.
	Cluster	26	10½	21	200	230	300/900	d-c.
	Cluster	26	10½	21	200	230	300/900	d-c.
	Cluster	26	10½	21	200	230	300/900	d-c.
Tandem mill	Cluster	18	8½	16½	150	230	400/1200	d-c.
	Cluster	18	8½	16½	150	230	400/1200	d-c.
	Cluster	18	8½	16½	150	230	400/1200	d-c.
Single stand	Cluster	26	8½	16½	150	230	400/1200	d-c.
Tandem mill	Two-high	10	10½	....	75	230	400/1200	d-c.
	Two-high	10	10½	....	75	230	400/1200	d-c.
	Two-high	10	10½	....	75	230	400/1200	d-c.
Single stand (two units)	Two-high	18	13	....	100	230	400/1200	d-c.
Single stand (two units)	Two-high	18	10½	....	75	230	400/1200	d-c.
Single stand (two units)	Two-high	10	8½	....	75	230	400/1200	d-c.
Single stand	Two-high	26	18	....	150	230	400/1200	d-c.
Single stand reversing	Four-high	12	9½	22	300	230	400/1200	d-c.
Single stand reversing	Four-high	29	9¾ or 14	33	1250	600	175/350	d-c.



C. W. WEESNER

CHIEF METALLURGIST

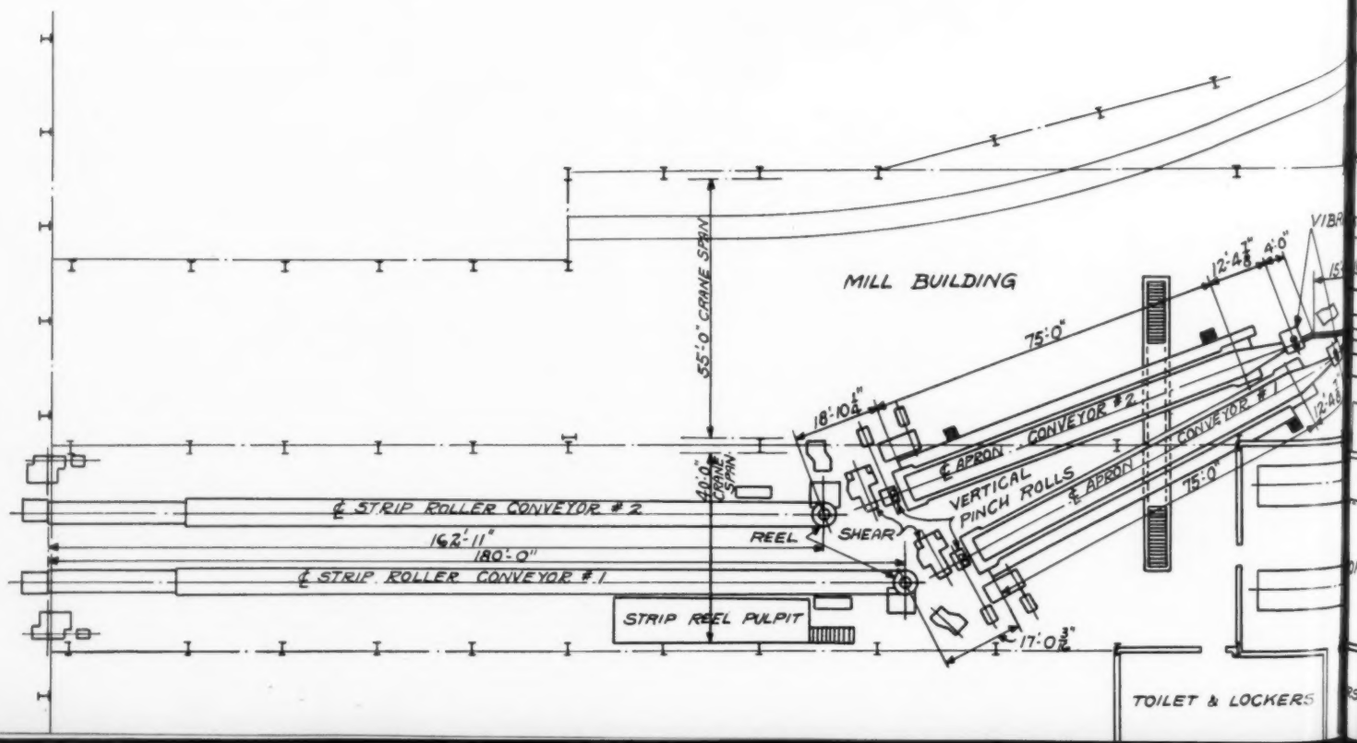
steel. About 70 per cent of the product is shipped in coil form, the balance in cut lengths.

Steel to supply the rolling mills comes largely from the Lowellville plant by rail, and is unloaded in a billet and slab yard which runs across the ends of the rolling mill buildings.

The continuous strip mill, a 24 in. unit at present, is the outgrowth of a narrower mill which was rebuilt and widened in 1932. As now constituted, the mill consists of five roughing stands, four edging stands, and four finishing stands. Strip is produced in widths ranging from 3¾ in. to 22½ in., and in gauges down to .035 in. Slabs for the mill, ranging 2–4 in. thick, 4–22 in. wide and up to 30 ft. in length are heated in a single 30 ft. x 47 ft. continuous heating furnace, side charge, side discharge. The slabs are brought to the furnace from power operated skids over a furnace charging conveyor, extending back into the slab and billet yard. Pushers located at the back end of the furnace move the slabs through the furnace, while another push-out mechanism ejects the slabs, one at a time, out into the mill. The furnace is fired with producer gas supplied from a single automatic producer. As the slab leaves the furnace it passes through an up-and-down-cut shear, whereby slabs to the mill may be sheared to almost any length desired.

The first unit of the mill train is a 16 in. vertical edger, located only 10 ft. 5 in. from the furnace, and driven by a 250 hp., 240–800 rpm., 600 volt d-c. motor. Following this stand at a distance of 5 ft. 3 in. is the first rougher, a two-high 19½ in. x 24 in. unit. Four more two-high 24 in. roughers follow, spaced respectively 9 ft. 6 in., 18 ft. 0 in., 9 ft. 6 in., and 18 ft. 0 in. from the preceding stand. These stands employ rolls of 17½ in., 17¾ in., 18 in., and 18½ in. diameter, respectively. All five of the roughing stands are driven through a line shaft and bevel gears by a single 4500 hp., 150–450 rpm., 600 volt d-c. motor. Three 12 in. vertical edgers are installed 9 ft. behind No. 2, 4 and 5 roughing stands. Each of these edgers is driven by a 100 hp., 250–1062 rpm., 600 volt d-c. motor.

Following the last edger at a distance of 26 ft. 6 in. is the first finishing stand, followed by three more spaced



L. G. MEHLER

SUPERINTENDENT OF BLAST FURNACE, LOWELLVILLE

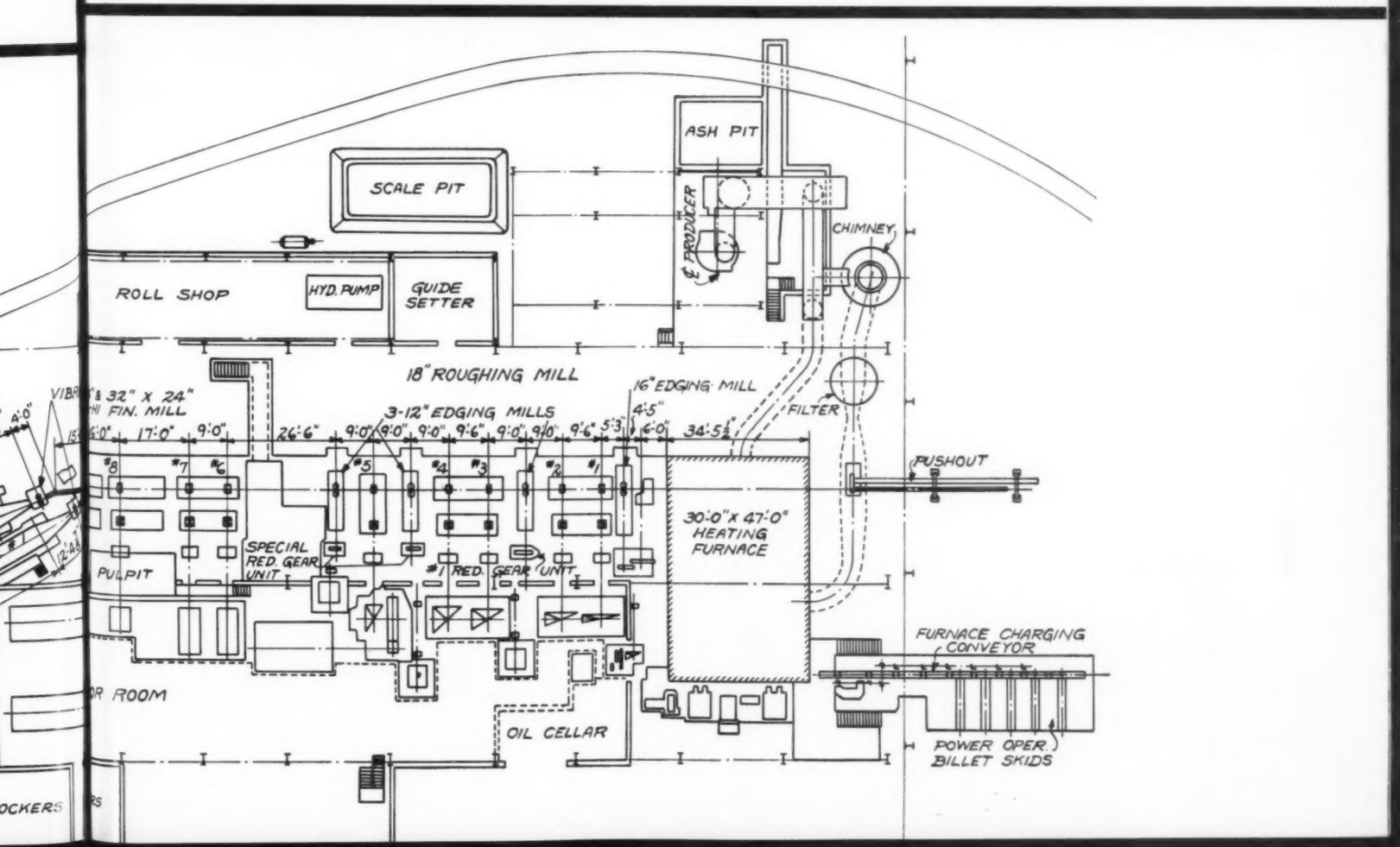
C. W. DIVEN

SUPERINTENDENT OF HOT MILLS, SHARON

respectively at 9 ft., 17 ft., and 16 ft. These stands are all four-high, 15¼ in. and 32 in. x 24 in., and are individually driven by 600 volt d-c. motors, the first two of 1000 hp., and the last two of 1250 hp. These drives operate at 103.5–253 rpm., 137–326 rpm., 213–500 rpm., and 312.5–625 rpm. respectively.

Speeds through the mill are therefore as follows:

Stand	Motor rpm.	Gear ratio	Roll rpm.	Strip speed. ft. per min.
1	150–450	23.35	6.41–19.23	32.6–98
2	150–450	11.63	12.845–38.537	59–177
3	150–450	6.71	22.327–66.985	104–312
4	150–450	4.13	36.245–108.73	171–512
5	150–450	2.74	54.875–164.61	265–796
6	103.5–253	Direct	103.5–253	413–1010
7	137–326	Direct	137–326	546–1300
8	213–500	Direct	213–500	850–2000
9	312.5–625	Direct	312.5–625	1245–2490



M. F. COON

ASSISTANT CHIEF ENGINEER

It is to be noted that the delivery speed of this mill is higher than those of the newer wider strip mills.

The vertical edging stands are equipped with sleeve bearings. The first rougher runs in bronze and babbitt bearings, while oil film or composition bearings are used interchangeably in the remaining roughers. The four high finishing stands are provided with roller bearings on both work rolls and back-up rolls.

Water for descaling and other special mill purposes is supplied from two triplex pumps rated at 310 gal. per min. at 1000 lb. per sq. in., each driven by a 250 hp., 2200 volt motor, and one 600 gal. per min., 500 lb. centrifugal pump driven by a 300 hp., 2200 volt motor.

Screwdowns on the two-high roughing stands are manually operated, while those on the four-high finishers are driven by two 7½ hp. d-c. motors.

Throughout the entire mill, no driven table rollers are installed, the steel being carried through entirely by means of suitable guides and looping chutes. Three pneumatic loopers are installed between the finishing stands.

Leaving the mill, the hot strip passes through a twist guide, in which it is turned through 90 degrees within a space of about 20 ft. In this on-edge position, the strip may be switched through either of two guide troughs leading into vibrators. The oscillating action of the vibrator puts the strip, still on edge, out on to a 75 ft. apron conveyor in a series of serpentine waves. The apron conveyors extend at an angle with the mill line, and lead to vertical pinch rolls and vertical coilers, driven by 35 hp. motors. From the coilers, two coil conveyors carry the coils to the loading building, a distance of about 170 ft.

Cold rolling facilities at Sharon are provided by a group of mills totaling twenty stands, of various sizes and types.

The motor-room, paralleling the hot mill building, is about 200 ft. long x 45 ft. wide, and contains all of the main mill drive motors. It is to be noted that all of the drives are adjustable d-c. motors, necessitated by the close spacing of the mill stands. These motors are operated under variable voltage control, and receive power from two dual motor-generator sets, each composed of two 2300 kw., 600 volt d-c. generators and a 5600 hp., 2200 volt, 514 rpm. synchronous motor.

Three other finishing mills are installed, an 8 in. mill, a 9 in. mill, and a 10 in. mill. The 8 in. mill consists of

ROBERT FINNIE

CHIEF ROLL DESIGNER

JOHN BIDNER

SUPERINTENDENT OF OPEN HEARTH, LOWELLVILLE

five stands of three-high mills, 8 in. x 10 in., followed by a chill pass. The first five stands are placed side by side in a looping train, all driven by an 800 hp., 350–600 rpm., 230 volt d-c. motor. The chill stand is driven by a 350 hp., 450–600 rpm., 230 volt d-c. motor. Billets, 1¾ in. square, are heated in a single continuous furnace. This mill produces material ⅜ in. to 1 in. wide and from No. 23 gauge to 3/16 in. in thickness.

The 9 in. mill is composed of a continuous roughing

This view shows a tandem cold mill of the cluster type, with all rolls running in roller bearings.

train of four 12 in. stands, spaced on 3 ft. 4 in., 24 ft. 7 in., and 3 ft. 4 in. centers. These stands are driven, at respective speeds of 43–86 rpm., 62–125 rpm., 86–173 rpm., and 125–250 rpm., by a 500 hp., 190 rpm. motor. Spaced 60 ft. distant are four 9 in. stands in a looping train, driven by an 800 hp., 250–500 rpm. motor. These stands are followed by a chill stand driven by a 500 hp., 250–500 rpm. motor. This mill is served by one continuous heating furnace. The product of the 9 in. mill ranges 1/16 in. to 1¾ in. wide and No. 22 gauge to ¼ in. thick.

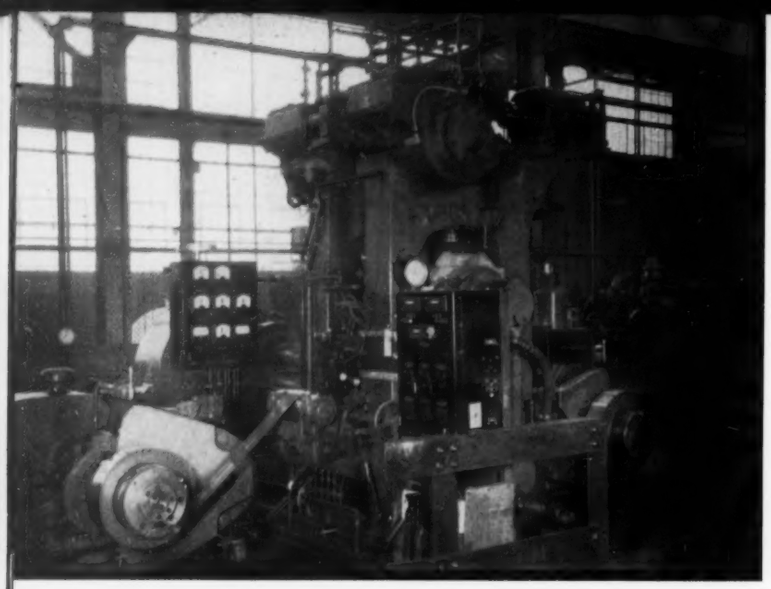
H. W. LOWMILLER

SUPERINTENDENT OF COLD MILLS, SHARON

The 10 in. mill produces material ranging 1 7/16 in. to 4¾ in. in width, and No. 20 gauge to ¼ in. in thickness. Billets for this mill are heated in a 30 ft. continuous recuperative side charge, side discharge furnace fired with producer gas. The mill is similar in layout to the 9 in. mill, consisting of four 12 in. roughing stands in tandem, driven by a 500 hp., 110 rpm. motor, followed by four 10 in. looping stands and a chill pass. The looping train is driven by a 1200 hp. 200–400 rpm. motor and the chill pass by an 800 hp., 350–600 rpm. motor.

Power for the d-c. motors driving the small mills, as well as for d-c. auxiliary motors, is furnished by three dual motor-generators, each consisting of two 1000 kw., 250 volt d-c. generators driven at 720 rpm. by a 2800 kva. 2200 volt synchronous motor, and one set composed of two 750 kw., 250 volt generators and a 2000 kva., 2200 volt, 720 rpm. synchronous motor.

Descaling sprays on the three small mills are supplied from two centrifugal pumps of 600 gal. per min., 500 lb. pressure, each driven by a 300 hp. motor.



One four-high reversing cold mill is provided, while a second unit of the same type is under construction.

The main pickling department consists of two adjacent buildings 375 ft. long x 69 ft. and 39 ft. 8¼ in. wide. Here are housed four continuous pickling lines. One of these is arranged with sixteen coiling heads, so that sixteen strands may be run. This unit has a single large pickling tank 142 ft. 6 in. long x 10 ft. 3 in. wide, of concrete construction, brick lined. A wash tank and a drying oven are placed immediately after the pickling tank.

A second unit consists of a brick lined concrete tank 99 ft. 3 in. long x 4 ft. 3 in. wide, followed by a cold water tank, a hot water tank, a drier, a muriatic acid solution tank and a galvanizing pot. Thus, strip may be pickled and galvanized in one continuous operation. An 8-head coiler permits the running of eight strands through this unit.

Another unit, similar but smaller, has a pickling tank of concrete construction, 65 ft. long x 3 ft. 6 in. wide, followed by a rinse tank, a scrubber, a flux tank, and a galvanizing pot. In yet another line, strip may be continuously coated with tin or terne.

A batch tub pickler is also installed, consisting of four acid tanks, two water tanks, and two lime tanks, each 26 ft. long.

Cold rolling facilities are provided by a group of mills totaling twenty stands. There is one tandem unit of four stands, 10½ in. and 21 in. x 26 in., of the cluster type, using four back-up rolls instead of the more usual two. Roller bearings are used on work rolls and back-up rolls. These stands are each driven by a 200 hp., 300–900 rpm., 230 volt d-c. motor, while a 50 hp. motor drives the reel. Gear ratios and mill speeds on this unit are as follows:

Gear ratio	Roll rpm.	Strip speed, ft. per min.
13.72	22.2– 66.6	67–201
9.29	32.3– 96.9	89–267
7.59	40.3–120.9	111–333
6.7	45.4–136.2	125–375

Screwdowns are operated by two 7½ hp. 230 volt d-c. motors.

Another tandem cold mill consists of three cluster stands, 8½ in. and 16½ in. x 18 in., also equipped with roller bearings. Each stand is driven by a 150 hp., 400–1200 rpm., 230 volt motor. A 35 hp. motor is applied to the reel. Mill speeds are as follows:

Gear ratio	Roll rpm.	Strip speed, ft. per min.
12.64	31.75– 95.25	77–231
8.11	49.4 –148.2	110–330
7.15	56.1 –168.3	125–375

A third tandem train is composed of three two-high stands, 10½ in. x 10 in., equipped with oil film bearings. This unit operates at the following speeds:

Gear ratio	Roll rpm.	Strip speed, ft. per min.
15.05	26.7– 80.1	73.5–220.5
10.6	38.1–114.3	105–315
9.2	43.3–129.9	119–357

Each stand is driven by a 75 hp., 400–1200 rpm., 230

W. W. HARTZELL

SUPERINTENDENT OF MILLS, LOWELLVILLE

volt d-c. motor, and a 20 hp. motor drives the reel. The screwdowns are manually controlled.

Single stand mills, as follows, are also provided:

One cluster mill, 8½ in. and 16½ in. x 26 in., driven at speeds ranging 56.1–168.3 rpm., 125–375 ft. per min., through a gear reduction of 7.15 ratio, by a 150 hp., 400–1200 rpm., 230 volt d-c. motor.

Two 13 in. x 18 in. two-high stands, driven by a 100 hp., 400–1200 rpm. 230 volt d-c. motor at speeds of 35.4–106.2 rpm., 125–375 ft. per min. through a gear reduction of 11.5 ratio. A 35 hp. motor is used on the reel.

Two 10½ in. x 18 in. two-high stands; gear ratio 9.21; speeds 43.3–130 rpm., 125–375 ft. per min.; motor, 75 hp., 400–1200 rpm., 230 volt, d-c.; reel, 20 hp.

Two 8½ in. x 10 in. two-high stands; gear ratio, 7.6; speeds, 53–159 rpm., 125–375 rpm.; motor 75 hp., 400–1200 rpm., 230 volt d-c.; reel, 20 hp.

One 18 in. x 26 in. two-high stand; gear ratio, 21.5; speeds 18.6–55.8 rpm., 90–270 ft. per min.; motor 150 hp., 400–1200 rpm., 230 volt d-c.; reel, 35 hp.

One four-high reversing mill, 9½ in. and 22 in. x 12 in., driven by a 300 hp., 400–1200 rpm., 230 volt d-c. motor at speeds of 90–270 rpm., 223–670 ft. per min., through a gear reduction of 4.45:1. Two 100 hp. motors drive the two reels, and two 7½ hp. motors operate the mill screws. The stand is equipped with roller bearings on the work rolls and oil film bearings on the back-up rolls.

All of the fore-mentioned cold mills receive their power from two motor generator sets, one a dual unit of two 1000 kw., 250 volt generators driven at 720 rpm. by a 2800 hp., 2200 volt synchronous motor, and the other a 500 kw. set driven by a synchronous motor of 1100 hp., 514 rpm.

The two-high mills are variously equipped with roller or oil film bearings.

Under construction at the present time is another four-high reversing mill. This is a 29 in. unit using 33 in. diameter back-up rolls and so arranged as to use work rolls of either 9¾ in. or 14 in. diameter. Work rolls run in roller bearings, and the back-up rolls in oil film bearings. The mill is a direct drive, from a 1250 hp., 175–350 rpm., 600 volt d-c. motor. Mill speeds are 446–892 ft. per min. or 640–1280 ft. per min., depending on which size of work roll is used. The two reels are each driven by a 300 hp., 600 volt motor, and a 200 hp. motor powers a set of tension rolls. A separate motor generator set is provided for this mill, composed of a 1250 kw. main generator, a 250 kw. reel generator, a 100 kw. booster, and a 50 kw. exciter, all driven by a 2000 hp., 2200 volt synchronous motor.

Annealing facilities include four double chamber box annealing furnaces, coal fired; two portable circular natural gas-fired annealing covers with eight bases; two portable rectangular covers, also fired with natural gas, with eight bases; and three circular electric annealing bells, with ten bases.

With the exception of cold rolling, all facilities for the finishing of stainless steel is grouped in one building.

Coiled steel strip may be annealed in electrically heated portable bell type furnace of the type shown here.

Here are located two continuous annealing furnaces, each designed for the accommodation of eight strips. Three continuous pickling lines are also installed, one capable of taking eight strands, another, six strands, while the third unit is somewhat smaller. Various polishing, inspection, and other finishing equipment is provided.

All electric power is purchased from the utility company serving the district. An outdoor sub-station contains one 12,000 kva. bank and one 6000 kva. bank of transformers, 66,000–2200 volts. The plant, which represents a basic 2200 volt connected load of 17,810 kva., is normally served by the 12,000 kva. bank, with the 6000 kva. bank as a spare. Electrical equipment in the plant includes 1392 motors (1 hp. or larger), totaling 32,747 hp.

Steam for miscellaneous plant usage is generated in three boilers, each rated at 501 hp., fired with pulverized coal. Located adjacent to the boilers are four automatic gas producers which supply gas to the heating furnaces of the 8 in., 9 in., and 10 in. mills.

Service water is pumped from the Shenango River. The pump house includes two 16 in. centrifugal pumps, each of 9500 gal. per min. capacity, and two 12 in. centrifugal pumps, 3500 gal. per min. each. Sand filters purify the water used for descaling, bearings, roll necks, etc. Drinking water is obtained from four deep wells.

H. L. SCHELL

SUPERINTENDENT OF STAINLESS DEPARTMENT, SHARON

ADVERTISING PAGES REMOVED

Here is your medium

For Cataloging Your Products to the

TO YOU, as a manufacturer of steel mill equipment or supplies, "The Modern Strip Mill" presents a dual opportunity. It affords the chance to catalog your complete line of products in such a way that the information is available to the user when most desired. It also affords permanent identification of your part in one of the greatest technological developments in the history of the steel industry. This great step in the steel industry represents a development of 15 years, with an investment of $450,000,000.

At the request of numerous operating officials and engineers, the Association of Iron and Steel Engineers is completing and coordinating the complete descriptions of the 28 wide strip mills in the United States, together with a digest of strip mill practice. As such, this publication, "The Modern Strip Mill," will contain vital information of interest to the engineering, operating and supervisory personnel of the steel industry, and will be repeatedly consulted by these men.

The contents of this publication will be arranged so that you may catalog and identify your products in associated editorial sections. Your advertising will follow the editorial section to which your products are directly related. You can't afford to miss this opportunity of being a part of one of the greatest publications ever issued to the steel industry. To be issued August 1st, 1941. Closing date for advertising copy, June 1st.

For further information write the

ASSOCIATION OF IRON AND STEEL ENGINEERS

1010 EMPIRE BUILDING PITTSBURGH, PENNSYLVANIA

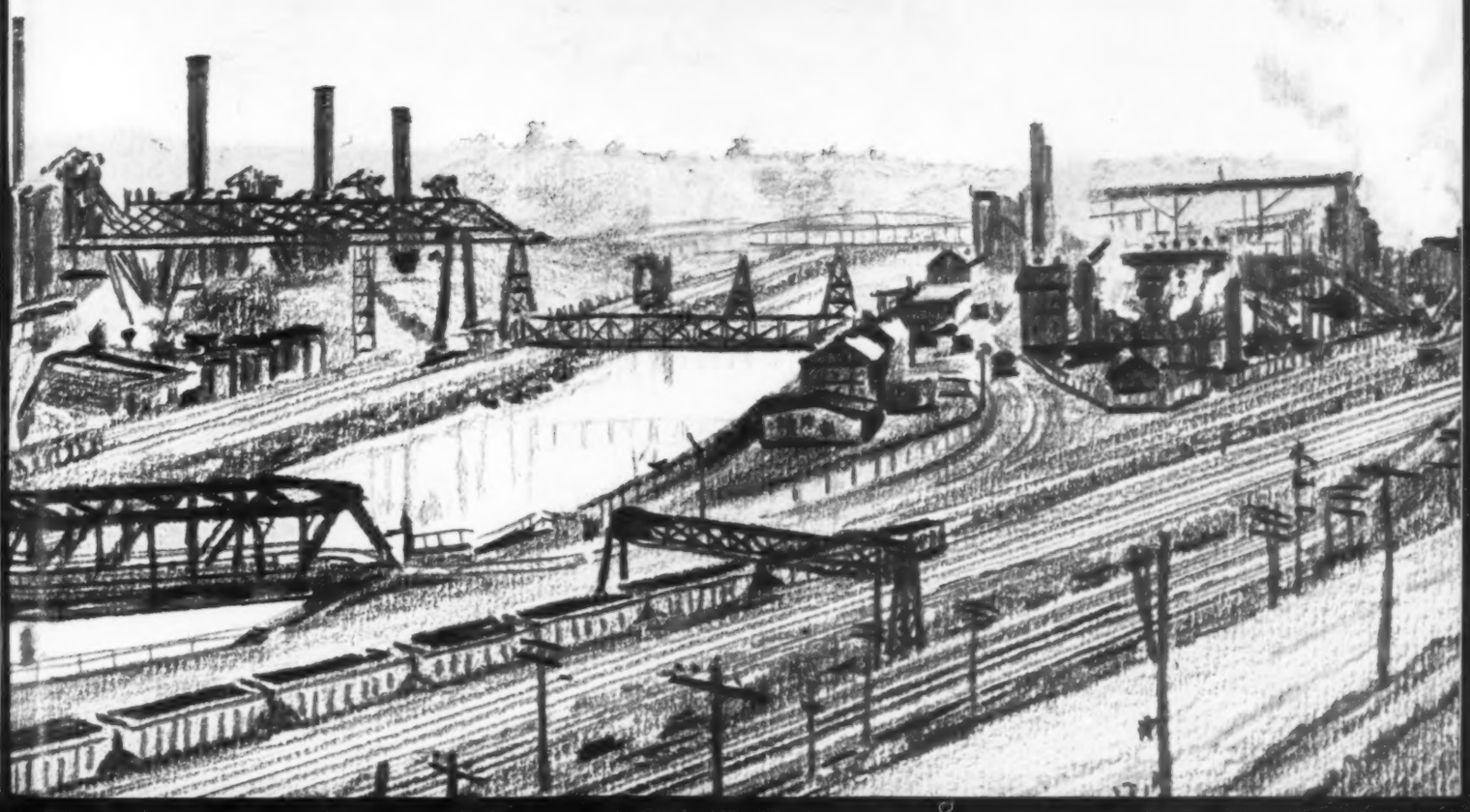
Annual Spring Conference

ASSOCIATION OF IRON AND STEEL ENGINEERS

YOUNGSTOWN, OHIO

OHIO HOTEL

MONDAY, APRIL 28, 1941



Authors and Officers

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OTTO de LORENZI

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STANLEY GRAND-GIRARD

FREEMAN H. DYKE

L. L. FOUNTAIN

H. A. TRAVERS

W. H. BENNETT

PROGRAM

(EASTERN STANDARD TIME)

9:30 A. M.

Technical Session

Chairman
J. L. MILLER, *Assistant Chief Combustion Engineer,* Republic Steel Corporation, Cleveland, Ohio.

Vice-Chairman
L. N. McDONALD, JR., *Chief Power and Fuel Engineer,* Carnegie-Illinois Steel Corporation, Youngstown, Ohio.

"Stoker Applications for Combination Firing of Boilers"
By OTTO de LORENZI, Combustion Engineering Company, Inc., New York, New York.

"Maintenance of Instruments and Control in the Steel Plant"
By R. A. WEIKEL, Brown Instrument Company, Philadelphia, Pennsylvania.

1:30 P. M.

Inspection Trip

SHARON STEEL CORP.

An inspection trip will be made through the Sharon Works of the Sharon Steel Corporation, Sharon, Pennsylvania. All guests must use the special buses which will leave the Ohio Hotel promptly at 1:30 P.M.

6:30 P. M.

Dinner

BALL ROOM, OHIO HOTEL

8:00 P. M.

Technical Session

Chairman
STANLEY GRAND-GIRARD, *Superintendent of Maintenance,* Sharon Steel Corporation, Sharon, Pennsylvania.

Vice-Chairman
FREEMAN H. DYKE, *Superintendent,* Blooming, Bar and Hot Strip Mills, Wheeling Steel Corporation, Steubenville, Ohio.

"Grounded Direct Current Systems for Steel Mills"
By H. A. TRAVERS and L. L. FOUNTAIN, *Power System Engineers,* Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania.

"Operating Problems in Bar Mills"
By W. H. BENNETT, *Superintendent,* Gautier Department, Bethlehem Steel Corporation, Johnstown, Pennsylvania.

JOINT MEETING

CLEVELAND AND PITTSBURGH DISTRICT SECTIONS

of the

ASSOCIATION OF IRON AND STEEL ENGINEERS

and the

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Tuesday, May 27, 1941

BELDEN HOTEL

CANTON - OHIO

PROGRAM

(Eastern Standard Time)

6:30 P. M.
DINNER — BALL ROOM

8:00 P. M.
TECHNICAL SESSION

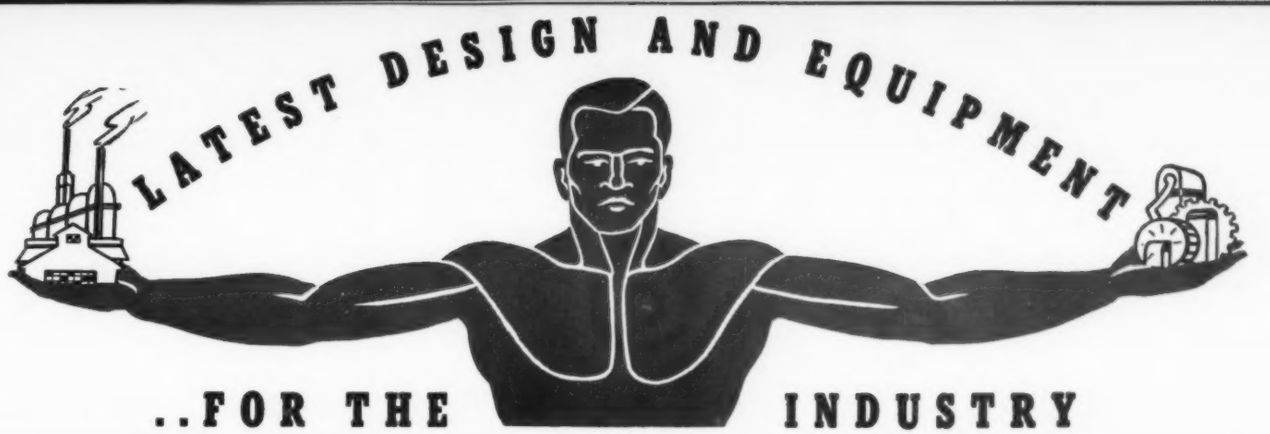
"Fundamental Considerations in Supplying Power to Arc Furnaces"
By F. M. Starr and O. B. Falls, Central Station Engineering Department, General Electric Company, Schenectady, New York.

"A Report of Tests Showing Transient Over-Voltages of Arc Furnaces"
By Z. W. Whitehouse, *Electrical Superintendent,* Republic Steel Corporation, Canton, Ohio, and C. C. Levy, *Industry Engineer,* Metal Working Section, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania.

Chairmen

C. T. SINCLAIR, A. I. E. E. T. B. McELRAY, A. I. S. E.

PLEASE MAKE EARLY RESERVATIONS
Association of Iron and Steel Engineers
1010 Empire Building
Pittsburgh, Pennsylvania



REPUBLIC TOPS FORMER RECORDS OF PRODUCTION

▲ Republic Steel Corporation broke all its previous records for steel ingot production during March. In responding to the need for steel for national defense, as well as to take care of normal requirements of industry, every single steel-producing department is reported by company executives to have established new production records for the month. Employment and pay rolls were likewise at record peaks, the latter approximately $10,500,000 for March.

Output totaled 721,243 net tons of steel ingots, a greater tonnage than during any single month since the corporation was organized in April, 1930. This record shattered one established only two months previously, in January, 1941, when the production reached a peak of 672,729. The record previous to this had been made in October, 1940, with 589,121 net tons.

During March the corporation shipped approximately 540,000 tons of finished steel, another all-time record.

NEW FACILITIES ADVANCE ALLOY STEEL PRODUCTION

▲ Copperweld Steel Company, upon completion of four additional electric melting furnaces at the company's Warren, Ohio, plant, will have a monthly ingot capacity of approximately 20,000 tons and will be one of the country's largest producers of electric furnace steels. Upon completion of the current construction program the company will be operating two electric furnaces producing 40-ton heats (now in operation); one electric furnace producing 50-ton heats, which began operation about April 10; one electric furnace producing 14-ton heats, beginning operation about April 25; and two electric furnaces each of which will produce 10-ton heats, one in operation April 5, the second to be ready about May 1.

Copperweld also announces that work is progressing rapidly on the new 12 in. mill at Warren, which is scheduled for completion about May 1. Additional heat-treating furnaces now building and scheduled for completion about May 1 will increase the plant's heat-treating capacity to approximately 3000 tons per month.

Featured in Copperweld's melting setup are the battery of three smaller electric furnaces installed to take care of the increasing demand for special steels.

COLUMBIA STEEL ADDS NEW ELECTRIC FURNACE

▲ Columbia Steel Company has announced that a standard type Heroult electric furnace has been added to the foundry department at the Pittsburg, California, plant. The size of the furnace was not announced because of defense restrictions.

The new furnace supplements the existing open hearth melting facilities and for the present will be principally engaged in casting national defense orders requiring special steel composition.

BETHLEHEM TO REBUILD OLD COKE OVEN BATTERY

▲ Bethlehem Steel Company has awarded a contract to Koppers Company, Engineering and Construction Division, for the rebuilding of a battery of old type Koppers coke ovens into a battery of 51 modern Koppers-Becker ovens at Bethlehem's Northhampton plant, Bethlehem, Pennsylvania. The ovens are to be ready for operation early in 1941.

DEVELOP SAFETY TONGS FOR ANNEALING COVERS

▲ A new type automatic "Safe-T-Tongs" has been designed by the Heppenstall Company for one of the large steel mills to lift annealing covers from stacks of steel in coil form. Made of forged nickel-chromium-molybdenum steel, corresponding to SAE 4340, heat treated to provide ample strength along with toughness to resist shock loads, these tongs eliminate the necessity of a ground man placing chains or hooks on the extremely hot covers.

Being fully automatic, all that is required with the new automatic safety tongs is to lower them on the work and the tongs do their job without the aid of a ground man.

These tongs were first used in steel mills but during the past four years, types have been developed for lifting pipe, wire, and other similar mate-

These new tongs are fully automatic and eliminate the danger of having a man on the ground.

rials. Lifting capacities run as high as 200,000 lb.

In plants where material has to be handled by crane or hoist, which includes practically every industry, the use of automatic "Safe-T-Tongs" is said to decrease hazards to life and limb, and to cut lost time to a minimum.

NEW CAPACITORS SHOW CONSIDERABLE SAVING

▲ At the end of their first 14 months of operation a group of sixty 15 kva. Westinghouse Electric and Manufacturing Company's capacitors installed at a southern ore refinery sliced $6900 off the plant's power bill, raised a power factor of 78 per cent to a near unity value of 92, and in the short time of only 14 months have completely paid for themselves.

The refinery is entirely electrified, using squirrel-cage induction motors, for the most part, to drive the various equipment. The loading of these motors, due to the nature of the product handled, averages about 66 per cent of their full load rating, giving rise to low operating efficiencies with consequent low power factor and heavy lagging currents. The operating power factor of the plant before the installation of capacitors was 78 per cent.

Power was purchased at 2200 volts from the local utility and was reduced at the plant to 440 volts in their own substation. Charges were based on a monthly kva. demand, plus an energy rate. Energy in excess of 250 kwh. per kva. of billed demand was obtained at a rate of 1.5 mils less than the standard energy rate.

The company management, realizing that raising the plant power factor would increase the number of kwh. obtainable at the lower energy rated, and at the same time reduce the kva. demand, decided to install capacitors.

Sixty Westinghouse capacitors, each unit rate 15 kva. at 460 volts, were installed in distributed banks, one bank to each feeder supplying a low power factor load. The capacitors are in the circuits continuously being switched out only at infrequent intervals for inspection.

Results of the installation were noticeable immediately. Load currents on the capacitor equipped feeder circuits dropped. The plant power factor rose from a comparatively low 78 per cent to a near unity value of 92 per cent with a corresponding elimination of useless wattless current. The existing feeders are now capable of carrying enough added load to permit a sizable plant expansion, if and when it should be needed.

Most important, however, was the effect of the capacitors on the power billing. With their elimination of wattless current, the monthly power bill for the first year's operation averaged $575 less than previously. This represents a yearly saving of $6900 in power costs.

The first cost of the capacitors approximated $7800. Slightly more than this amount has been saved in 14 months of operation, so that the capacitors have literally "earned their own keep." Since installation, no maintenance or repairs have been necessary.

TENNESSEE COKE PLANT ANNOUNCES EXPANSION

▲ A contract for expansion of its coke and by-product plant at Chattanooga, Tennessee, has been awarded by the Tennessee Products Corporation to the Wilputte Coke Oven Corporation of this city. Wilputte is a subsidiary of Semet-Solvay Company, a division of Allied Chemical and Dye Corporation.

The contract provides for the construction of 19 underjet by-product coke ovens of the latest type, together with necessary expansion of the associated by-product and benzol plants. The new ovens will have a yearly capacity of 130,000 tons of coke and will enable the Tennessee Products Corporation to supply additional coke to the Alcoa, Tennessee, plant of the Aluminum Company of America.

LARGEST MAGNET SPEEDS LOADING AND UNLOADING

▲ Speed is one of the vital factors, today, in loading and unloading freighters. This is largely because of the importance of keeping down demurrage expense.

To accelerate these operations, Cutler-Hammer, Inc., now announces a new 77 in. monster lifting magnet, which the company is now manufacturing. It is claimed that this is the world's largest.

This 77 in. lifting magnet has been known to lift approximately double the amount of material that the 65 in. magnet handled.

The first of the new 77 in. supermagnets is installed on a Great Lakes freighter, owned by the Columbia Transportation Company, a subsidiary of Oglebay, Norton and Company. The new magnet has a marked effect on loading and unloading time.

A 65 in. magnet was used on the same vessel to obtain a comparison of the lifting capacity of the 77 in. magnet. It was found that the new magnet would lift approximately double the amount of material that the 65 in. magnet would handle.

NEW ATMOSPHERE GAS FOR SURFACE DECARBURIZING

▲ Drycolene, the new atmosphere gas for heat treating metals, is now being used successfully by several industrial plants for heat treating their steel products without surface decarburization.

The new drycolene gas is the latest advancement in protective atmospheres for such operations as the scale-free hardening, bright annealing, sintering, and electric-furnace brazing of high carbon steels in which surface decarburization cannot be permitted. In the laboratory, the ideal gas for this purpose is dry nitrogen, but dry nitrogen is impractical for large-size furnaces since atmosphere cannot be kept sufficiently free of carbon dioxide, water vapor, or infiltered air.

The presence of carbon monoxide in drycolene, however, opposes the decarburizing action of these impurities.

Steel hardened in drycolene has been found to be hard right to the surface and has passed such tests for traces of surface decarburization as the Rockwell N ("superficial") test, weight change measurements, and photomicrographs.

For example, all three tests were made on SAE-52100 and SAE-1090 steels. Samples were heated in drycolene for two hours at 1500 degrees F., and quenched. Weight-change measurements showed slight increases in weight, indicating no decarburization. Rockwell hardness-comparison tests gave slightly higher converted N values than the C readings, indicating no decarburization. And photomicrographs showed absolute uniformity of structure extending right to the surfaces, which is generally further proof of no decarburization.

The drycolene producer is manufactured by General Electric Company, and is available in sizes of 200 and 750 cu. ft. per hr.; it is a gas-fired reaction chamber with a number of accessories, all mounted as one self-contained unit. Several burners of the refractory-screen type project through the side wall of the reaction chamber. At the top of the chamber there is a hopper for storing charcoal and feeding it down through a vertical retort. The hopper is provided with a cover for manual charging, and with fittings for optional vacuum charging.

Fuel gas	Estimated price of fuel gas	Drycolene cost per 1000 cu. ft. (cents)
Coke-oven gas	60 cents per thousand	29
Natural gas	40 cents per thousand	16
Propane gas	8 cents per gallon from tank car	24
Propane gas	25 cents per gallon from cylinders	57

The producer itself consumes hydrocarbon gases such as coke-oven, natural, propane, or butane gas. The hydrocarbon gas and air first pass through visual flowmeters to show the input volume of each. They then enter a gas-combustion controller, consisting of a mixer which automatically holds the proportions of gas and air constant under all conditions, a compressor, and a pressure regulator.

From the gas-combustion controller, the mixture goes through a self-closing fire check to the burners in the unit itself and burns within the combustion chamber, heating the charcoal in the retort to incandescence. The products of combustion travel through an externally mounted surface cooler, where most of the moisture is removed. An activated-alumina dryer may be inserted at this point if all the moisture must be removed to reduce the hydrogen content of the drycolene to the lowest point practical.

From here, the gas travels through the incandescent charcoal where further reactions take place and drycolene is formed. Any carbon dioxide or water vapor present is here converted into carbon monoxide and hydrogen. The gas after passing through a drop-

TRUFLO FANS...

Built Right TO BEAT THE HEAT

TRUFLO WALL FANS: Remove fumes and hot air from work areas to outside of buildings. 12 inch to 48 inch diameters, four and six blade types.

Summertime—and HOT weather—will soon be here. Now, when top production rates must be maintained, the comfort of your workmen is an important factor in keeping production at high levels. Truflo Fans lessen worker fatigue by supplying clean, cool air wherever it is needed.

All Truflo Fans are designed and built correctly for utmost in efficiency and economy of operation. Perfectly balanced one-piece aluminum alloy blades assure long motor life and low power costs...extra strong frames stand up longer under hard use... rugged wire guards protect against injuries.

There is a style and size of Truflo Fan for every cooling and ventilating job. Write for free illustrated literature on any of the following types:

TRUFLO PORTABLE COOLING FANS: Easily portable. Help keep efficiency high where work is hottest. 12 inch to 36 inch diameters.

PORTABLE COOLING FANS ● CRANE CAB FANS ● WALL FANS ● EXHAUST FANS ● BLOWERS ● ROOF VENTILATING FANS ● PENT HOUSE FANS

TRUFLO FAN COMPANY

554 MAIN ST., HARMONY, PA.

out chamber leaves through a filter which removes charcoal dust. It then passes through a visual flow meter which indicates the usable output rate.

Based on operating costs of a 750 cu. ft. per hr. drycolene producer operating at full capacity, the tabulation above shows the cost of producing drycolene. Estimates include 4 lb. of charcoal (at 2 cents per lb.) per thousand ft. of drycolene.

INCREASE LAMP LIFE WITH SHOCK ABSORBER

▲ Records kept by a large steel plant indicate the Model M-T lamp shock absorber greatly increases lamp life wherever lamps are subjected to vertical or horizontal shock. The fixture and lamp support floats in flexible sponge rubber, consequently absorbs shocks in all directions equally well. Metallic connection between fixture and vibrating structure is completely eliminated.

A synthetic rubber skin, that withstands corrosive atmospheres, assures long and satisfactory life from the sponge rubber mounting.

The new shock absorber, which is manufactured by the Lintern Corporation, is easily attached to any fixture accommodating from 100 to 750 watt lamp.

A Great Number of Variables

common to open hearth operation are eliminated by this Askania Control of Heat Input, Combustion, Furnace Pressure, and Automatic Reversal —one of eight open hearth furnaces that are under Askania Automatic Control in this plant.

As the call goes out for MORE STEEL —

THE importance of Askania Control for open hearth furnaces increases as the demand for steel grows. Askania systems like this open-hearth control tell the story of remarkably increased output at a time when *more steel* is needed.

Melting time has been reduced, charging time shortened, tap to tap time decreased, and of course all this makes possible far lower production costs.

In this plant ore heats are made requiring considerable time of the first helper to tap off the slag. With Askania Control taking care of all adjustments of fuel, air and automatic reversal, he can devote his time to taking care of the other important jobs so that the furnace produces maximum tonnage.

Open hearth control is needed *right now*—and Askania, with the freedom from trouble and maintenance that you know so well, is the *right* control.

ASKANIA REGULATOR COMPANY
1603 South Michigan Avenue, Chicago, Illinois

ASKANIA CHICAGO **ASKANIA CONTROL**

NEW ALUMINUM PLANTS UNDER CONSTRUCTION

▲ Reynolds Metals Company is constructing and equipping two new plants for the production of virgin aluminum ingots. One plant will be located in the vicinity of Bonneville Dam, Washington, and the other plant will be situated at Lister, Alabama, near Sheffield. Both plants are expected to produce a total of 100,000,000 lb. of aluminum ingots per year.

The Lister plant, which was begun last fall, was originally designed to produce 60,000,000 lb. of ingot aluminum a year, but specifications were changed so that its capacity would be 40,000,000 lb., because it was found that more power was available at Bonneville Dam. A part of the power available from Muscle Shoals was needed for the rolling mill at Lister.

TEN MILLION DOLLARS FOR NEW COKE PLANTS

▲ Contracts for the construction of two complete batteries of coke ovens, with by-product recovery equipment, were received by the Koppers Company. The two awards have a combined value of more than $10,000,000. The ovens are to be built for the Monessen Coke and Chemical Company and for the Weirton Steel Company.

The contract for the Monessen Coke and Chemical Company, a subsidiary of the Pittsburgh Steel Company, is for 74 Koppers Becker underjet ovens to be built at Monessen, Pennsylvania, adjacent to the blast furnaces of the Pittsburgh Steel Company. These ovens will have a total

(*Please turn to page 82*)

4 5 6 7 8 9 10 TOTAL
20 150 180 210 240 270 300 300
Dependable Economical Durable
IT'S THE DEVELOPMENT OF THE ROLL THAT RUNS-UP THE SCORE!
OHIO ROLLS
MOLYBDENUM CHILL ROLLS
CARBON STEEL ROLLS
NICKEL CHILL ROLLS
ALLOY STEEL ROLLS
FLINTUFF ROLLS
OHIOLOY "K" ROLLS
DENSO-IRON ROLLS
ALLOY IRON ROLLS
HOLL-O-CAST ROLLS
PLAIN CHILLED IRON ROLLS
THE OHIO STEEL FOUNDRY COMPANY
LIMA, OHIO

coal carbonizing capacity of approximately 700,000 tons a year.

In addition to the ovens and the coal and coke handling equipment, the contract covers the construction of a new plant for the recovery of tar, benzol, toluol, phenol, and sulphate of ammonia.

The contract for the Weirton Steel Company, a subsidiary of the National Steel Corporation, covers the construction at Weirton, West Virginia, of an additional battery of 45 coke ovens, of the same type as the ovens to be erected at Monessen. These additional ovens will increase the coal carbonizing capacity of the coke plant at Weirton by approximately 400,000 tons a year. They now have 111 Koppers ovens at this plant.

The Weirton contract also calls for the construction of a by-product plant which will handle the throughput of the entire plant, together with the recovery of benzol, ammonia and tar. There will also be extensive changes in the coal and coke handling system.

TREATED LAMPS RETAIN BRILLIANCY UNDER TEST

▲ Tests conducted in the John C. Dolph Company laboratories and in a nearby shipyard have disclosed that electric bulbs treated with Dolph's No. 253 clear glass coater do not darken after being illuminated continuously for 240 hr. (tests are still being run). Treated lamps were screwed into sockets and were held directly in the path of welding spatter for several minutes. The spatter did not pit nor adhere to the treated glass surface. Several untreated lamps were given a similar test and all became badly pitted after a few seconds. Two of these lamps were broken by the welding spatter.

Treated lamps were then connected to a power supply and subjected to dripping cold water. None of the lamps broke. This cold water test was made to check the durability of this coating for protection of drop light lamps used for exterior service.

The recommended method for coating lamps is to pour a necessary amount of the clear coater in a clean metal trough large enough to allow various sizes of lamps to be dipped up to the bottom of the socket base. Drill holes in strips of wood to hold as many lamps as is desired to treat in one operation. Secure the lamps in the wood strips by using a clip or wedge on the lamp base and then dip in the material. Slowly remove lamps from the coating material so as to provide an even surface and allow the treated lamp groups to air dry from 30 to 40 min. when they will be ready for immediate service. Three hundred fifty-six 40 watt lamps can be treated with a single gallon of the clear glass coater.

Glasses may be treated with clear glass coater by dipping or brushing. This should be applied at its original consistency. The coating will dry to handle in 30 to 40 min. at normal room temperature. The coating should be allowed to remain on port glasses throughout the period required for ship fitting. Tests conducted in the Dolph laboratories showed that three

Two 15-ton-100'-0" span Cleveland *all-welded* steel-mill cranes operating over continuous pickling lines.

WHERE UNINTERRUPTED CRANE SERVICE IS VITAL, PLAY SAFE WITH

CLEVELAND *all-welded* CRANES

In the big mills, on the jobs where crane service is vital, many Cleveland all-weldeds will be found because they can be depended upon to carry through peak loads without interruption.

You, too, will find it profitable to install Clevelands at those places where crane service *must* be available.

THE CLEVELAND CRANE & ENGINEERING CO.
Wickliffe, Ohio

CLEVELAND CRANES
ALL-WELDED OVERHEAD TRAVELING CRANES
Other products: CLEVELAND TRAMRAIL and STEELWELD MACHINERY

weeks after the coating material had been applied to the glass, it was easily removed in one piece without having to use a softening solvent or a metal scraper. For best results, port glass surfaces should be as free as possible from dirt and grease.

FULL CONTACTOR CONTROL FOR HEAVY DUTY TRUCKS

▲ Recently a heavy duty ram and fork truck incorporating full contactor control was shipped to a large steel manufacturer by the Baker Industrial Truck Division of the Baker-Raulang Company. This truck rated at 10,000 lb. capacity was equipped with both 36 in. forks and a 36 in. ram. The forks lift to 60½ in. and the ram to 70 in.

The control apparatus employed is of the same design as used in transportation service. It is rgugedly built to withstand severe usage and has had years of service to prove its applicability to heavy duty industrial trucks.

The maintenance of this new truck is low since the contactors are of the single unit type and are identical on the various motions. This results in interchangeability of contactors and reduces the number of renewal parts required for stock. The contactors are mounted on the panel as individual units. There are no nuts or bolts in the back requiring access when mounted.

These contactors are equipped with nitrited bearings and pins which require no lubrication and will last indefinitely. The main contacts are pure hard copper and have a long life in the most severe service. The contactor is rugged throughout and is in keeping with other apparatus required and used on this type of service. The master switch is of the double brake cam type which has proven successful in steel mill and transportation service. Each circuit at the master switch is broken twice by the quick action of the cam. All of the contacts are made of liberal amounts of silver, which guarantees against failure of contacts due to oxide.

The advantages of long life and low maintenance cost are assured in the automatic acceleration which this system makes possible. The time tactors are used to cut out steps of resistance in series with the travel motor and they are made to close in a definite time interval, therefore, insuring a definite time for acceleration. The time tactor has liberal contacts and is ruggedly built to meet the severe requirements of this type of service.

The No-Plug relay is a simple series coil relay with one set of contacts to open or close the circuit to prevent or start the progression of the control. This relay is set to close its contacts and start the progression of the control at a current which is slightly higher than the maximum starting current on the first point of the control. This relay requires that the current on the reverse motion be about equal to starting current before the control will progress and accelerate the motor in the reverse direction. This relay has heavy silver carbon contacts whose life will approximate the life of the truck. The bearings are a rugged pin point type having low friction, which results in a very fast and sensitive relay.

Interlocks are used on some of the contactors to guarantee the proper progression of the control. These interlocks are of the double brake type and are made for both in and out circuits. All contacts are silver, preventing failure due to oxide.

ON GUARD
against guesswork
GUARDING against production failures is a necessity at any time but particularly so when production schedules are being pushed at top speed. Hays indicating and recording instruments for steel mills accurately indicate combustion conditions in soaking pits, open hearths, annealing furnaces and slab mills—gas pressure indicators, air flow indicators, draft and pressure gages, both indicating and recording, give a constant picture of what's going on inside and guard against harmful, inefficient and costly errors. Write for information.
HAYS "DT" DRAFT RECORDERS SHOW TWO DRAFT VALUES, TWO PRESSURE VALUES, TWO DIFFERENTIAL VALUES OR A COMBINATION OF ANY TWO OF THESE. FOR SOAKING PITS, OPEN HEARTH, ANNEALING FURNACES, SLAB MILLS. ASK FOR PUB. 39-232.
The HAYS CORPORATION
COMBUSTION INSTRUMENTS AND CONTROL
MICHIGAN CITY, INDIANA, U.S.A.

POTENTIOMETER CONTROL FOR AUTOMATIC SYSTEMS

▲ A completely flexible program control system using potentiometer controllers has been announced by the Brown Instrument Company. The system is particularly adaptable to the steel and metal industry to provide completely automatic control of such heat treating processes as annealing, normalizing, carburizing and stress relieving. These applications require a peculiar combination of equipment all incorporated in an automatic system.

The basic instrument is a potentiometer type controller, and is usually a single point indicating or recording pyrometer although it is also possible to use the two or three record controllers, controlling at the same temperature. In order to accomplish a certain program of temperature control, the control index of the potentiometer type controller must be moved automatically from one point to another, either upscale or downscale.

The movement of the control index is governed by a control point drive motor which is mounted in the instrument. This reversible motor drives the control index in either direction desired with a minimum of coasting of the motor when the winding is deenergized. Obviously, it is impractical to supply a different special speed motor drive for each heating and cooling rate. Consequently, an adjustable current interrupting device is connected in series with each motor winding so that the speed of control index movement may be varied at will.

NOT PROMISES...
BUT PERFORMANCE
in Steel Mill Operations
Daily performance for more than 15 years on heavy steel mill equipment—that's the history of many Ross Valves and they are still rendering very satisfactory service.
During these 15 years, improvements have been made in all models of Ross Valves—now valve stems of stainless steel, improved valve seats that insure positive air seal over long period of use, essential parts forged and hardened to give longer service, improved design—but the basic principles remain the same.
From the beginning, Ross Air Valves have been built to take hard steel mill punishment—time has proven their dependability.
Bring your air control problems to Ross.
ROSS Air Control VALVES
THE BRIDLE FOR AIR HORSEPOWER
ROSS Operating VALVE COMPANY
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DETROIT, MICHIGAN
★ A SIZE AND TYPE FOR EVERY OPERATION FOR HAND, FOOT, MECHANICAL AND ELECTRICAL CONTROL ★

BORG-WARNER EXPANDS MILLS IN MIDDLE WEST

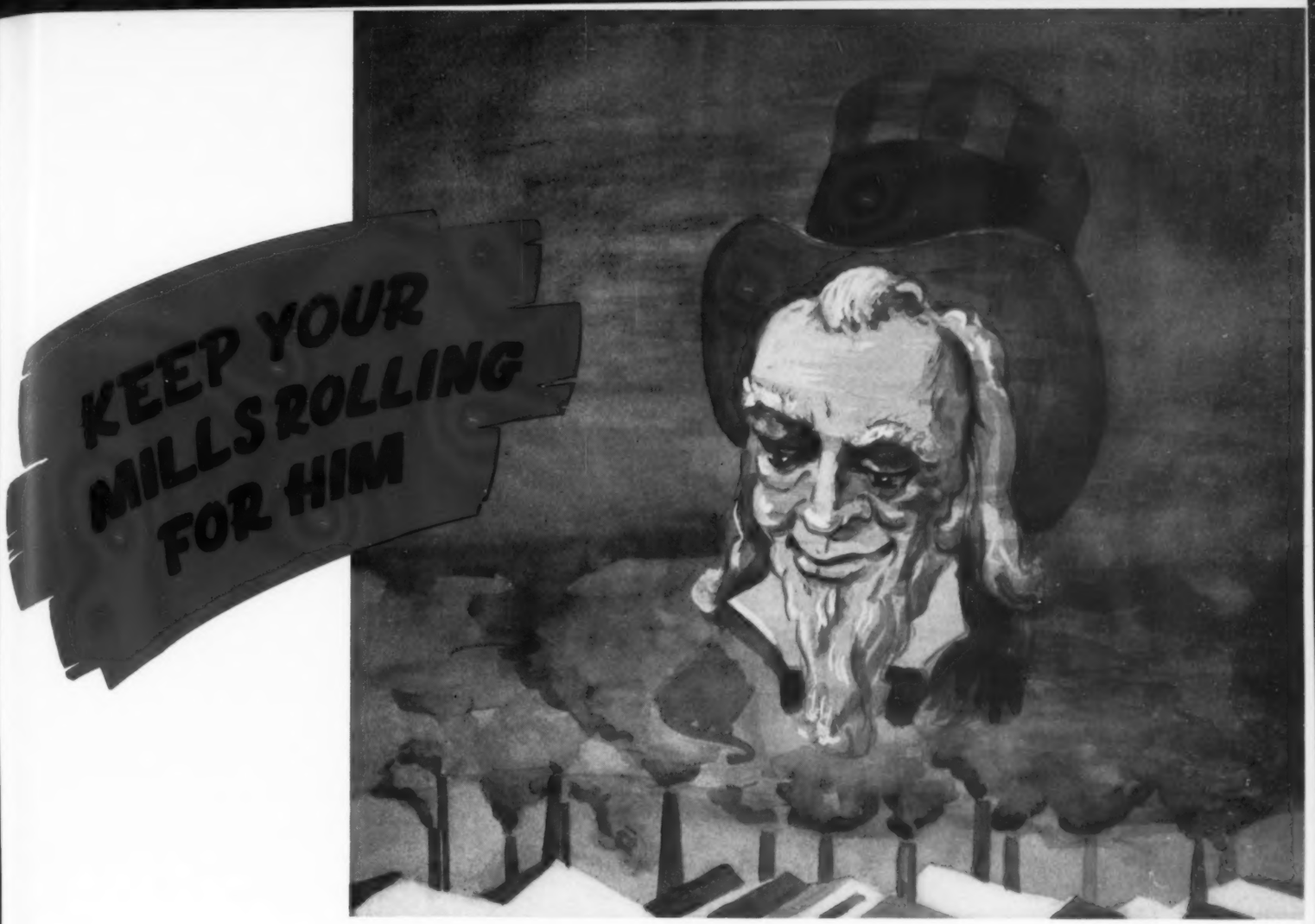
▲ Expansion of plants at Newcastle, Indiana, and Kalamazoo, Michigan, has been undertaken by Ingersoll Steel and Disc division of Borg-Warner Corporation. A third expansion at West Pullman, near Chicago, is close to completion. The Newcastle addition will be approximately 80 by 240 ft. A removable roof furnace with eight to ten ton capacity, ladles, grinding and chipping equipment, etc., will be installed in the new building, which is expected to substantially increase the firm's tonnage at this plant.

Increased furnace capacity will be installed at Kalamazoo, also. Expansion at West Pullman is for the defense shell contracts held by the company.

DEVELOP LARGER SIZE DIRECT FIRED HEATERS

▲ To meet a demand for larger size direct fired heaters, arising from the rapid construction and amortization requirements of the current industrial building boom, the Dravo Corporation has designed, built and already has in operation, a floor type direct fired heater with an output of 1,500,000 Btu. per hr.

Fired with either oil or gas, this heater embodies many of the features of the 1,000,000 Btu. per hr. size of



As Mills Become Busier -- Waste Becomes Costlier

How much of the vital power of your motors and generators is now going to waste due to poor commutation? To reduce that waste, Morganite engineers and metallurgists developed the Link Series, a full selection of brushes designed to stand up under the severe conditions of steel mill operation. Each brush is designed for a particular purpose—each to give the greatest efficiency at that particular job.

Morganite Brushes Are Better

Low Coefficient of Friction

Excellent Commutation

Quiet Operation

Long Life

Low Maintenance Costs

A variety of materials in many grades—carbon, graphite, electro-graphitic and metal graphite—can be obtained. Accurate, smooth ground faces assure excellent commutation. Precise dimensions give quiet operation.

Morganite Link Brushes are capable of handling high current density. Special grades have been perfected for use where fumes and gasses are encountered.

That is why Morganite is installed as standard equipment in many of the newest and largest plants. Let a Morganite engineer, backed by years of experience with steel mill commutating equipment, solve your problems.

MORGANITE BRUSH COMPANY, INC.

3302-3320 FORTY-EIGHTH AVENUE *Long Island City, N. Y.*

which there are several hundred in service. One new feature is the application of a tubular economizer, which acts to reduce the flue gas temperature to the lowest practicable limit. Efficiencies on test have exceeded 85 per cent.

It is of steel construction throughout and is designed to conserve floor space. Output per sq. ft. of floor space is about 30,000 Btu. Although an air heater, in many respects it reflects the latest boiler construction and design practice. For example, considerable so-called "black surface" is provided for absorbing the radiating effect of the flame, thus performing a function equivalent to that performed by the water walls in a modern boiler. This results in advantages such as low furnace temperature with consequent low brick work up-keep, and a comparatively simple convection or economizer effect. The combustion chamber is of welded steel plate, heavily corrugated and with a large steel fin surface welded thereon. The outer casing is made of steel plate of substantial thickness. The fans are located below the heater, thus taking the air at floor level where it is coldest. The heater is of the blow through type, thus assuring at all times an air pressure higher than the combustion chamber pressure. The combustion chamber is jacketed at every point with a rapidly moving stream of air and thus no insulation is required.

The heater can be converted from oil to gas or vice versa, at any time. The burning of either fuel reflects the latest combustion practice. Just sufficient brick work is provided to assure complete combustion and the application of controlled induced draft assures a constant CO_2. The fan capacity on these units, referred to intake conditions, is 18,000 cu. ft. per min.; approximately 20,000 cu. ft. per min. referred to outlet temperatures.

The heater is provided with the latest and most reliable safety controls that act to shut off the fuel in the event of flame or power failure, and the operation of the heater is automatically controlled in accordance with the outlet temperature or the temperature in the building.

The heater has discharge nozzles on top that can be adjusted to discharge the air in any given direction. These nozzles have adjustable horizontal louvres. The heater is designed to throw heat as far as 200 ft. if desired.

METHODS OF MEASURING PULSATING FLOW

▲ Regardless of the type of flow meter used, where there is pulsating flow involved, it is generally impossible to obtain readings which are directly proportional to the rate of flow. However, precautions may be taken which will reduce the pulsations so that only small errors in the readings will result. Pulsating flow is generally encountered in systems where reciprocating engines, pumps, and compressors are used. The intermittent action of such units creates pressure and velocity waves in the fluid, whether it be liquid or gaseous. The waves or pulsations invariably increase the flow meter readings, not because of the oscillation of the pen

CROUSE-HINDS CONDULETS

Superior conduit fittings and enclosures for every electrical wiring requirement

The Crouse-Hinds Company is the originator of Condulets and the largest manufacturer in the world of fittings for electrical conduit.

There are over 15,000 types and sizes in the Condulet line. All fields in which electricity is used for light and power have been covered. In addition to the common types, there are many Condulets designed to meet special requirements such as: *Arktite* circuit-breaking plugs and receptacles; Vaportight Condulets, for use where exposed to weather, moisture and steam; Dust-tight Condulets, for use in hazardous locations where combustible dust is present; and Explosion-proof Condulets for use in hazardous locations where the atmosphere contains flammable gases or vapors.

The Crouse-Hinds Company would be glad to have you submit any problems involving conduit fitting installations.

Type C with Tumbler Switch
Type FS with Pilot Light, Tumbler Switch and Plug Receptacle
Type FS with Vaportight Cover
Type ALC Cushion Fixture Hanger
Type VS Vaportight Portable Hand Lamp
Type GST with Receptacle Equipment
Type ARE *Arktite* Spring Door Receptacle Equipment
Type YSW Vaportight Circuit Breaker Condulet
Type VDA Vaportight Lighting Fixture with Reflector
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Type VC Vaportight Lighting Fixture
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Type EFSC Explosion-Proof Tumbler Switch Condulet
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back and forth on the chart, but because of the inability of the recorder to follow accurately each pulsation.

The errors which result from pulsating flow may be explained by the following example: Assume a steam flow meter with a maximum capacity of 10,000 lb. per hr. Then, if the pulsations of flow were such that at one instant the differential pressure was 48 in. of water and the next instant 3 in. of water, the flow corresponding to 48 in. water head would be 8000 lb. per hr. while for 3 in. head it would be 2000 lb. per hr. The inertia of the fluid in the pressure piping and of the mercury in the instrument prevents the recorder from following the quick changes in differential. The recorder would take a position corresponding to an average differential of 25½ in., and would thus register 5800 lb. per hr. However, with the flow for half the time at 8000 lb. per hr. and then at 2000 lb. per hr., the actual average flow would be 5000 lb. per hr. Therefore, the pulsating flow would result in the recorder reading 16 per cent high.

The inaccuracy due to pulsating flow may be much greater or much less than the amount given in the foregoing example, since the magnitude of the error depends upon the frequency and degree of pulsation, the volume and other characteristics of the piping and the compressibility of the fluid. However, in any case, it is highly important that pulsations be damped or eliminated in order to measure the flow accurately. Arrangements are recommended which successfully neutralize the pulsations and result in highly accurate readings.

Fig. 1

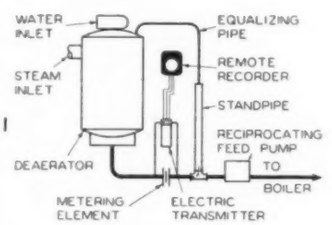


Fig. 2

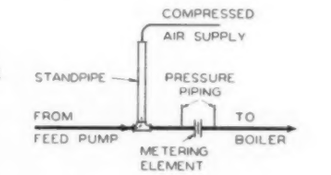
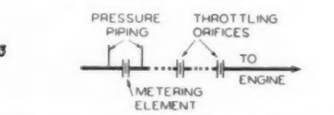


Fig. 3



Orifice on Suction Side of Reciprocating Pump

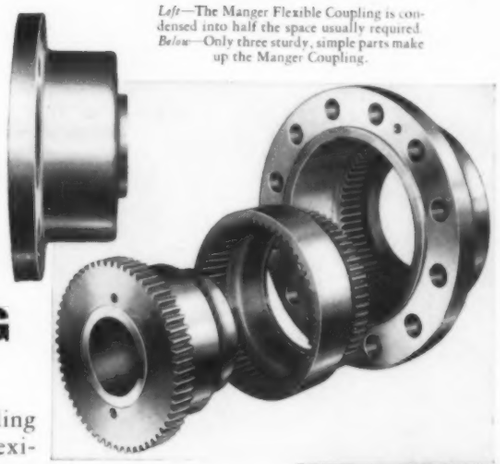
The patented method shown in Figure 1 enables a Cochrane flow meter to measure accurately water taken by a reciprocating pump from an open feed water heater or other receptacle having a free water surface. A stand-pipe located between the pump and orifice is vented back to the heater and absorbs the pulsations created by the pump. While the water level in the standpipe rises and falls, due to the pulsations, the flow through the orifice remains fairly constant and allows the meter to respond to a head corresponding to the average flow.

The vent line from the standpipe leads to the space above the free

50% LESS AXIAL CLEARANCE

WITH THE NEW MANGER FLEXIBLE COUPLING

Left—The Manger Flexible Coupling is condensed into half the space usually required. *Below*—Only three sturdy, simple parts make up the Manger Coupling.



The Manger Coupling provides complete flexibility with approximately one-half the axial clearance usually required in connecting a shaft directly to a flywheel, brake drum or flange. It also eliminates the dummy, pilot or stub shaft generally necessary.

Right—This diagram shows how the Manger Coupling connects a driving shaft to roll or pinion stand when the radial clearance is insufficient for a standard coupling.

The Manger Coupling is equally applicable for connecting two free-ended shafts, in combination with a solid, flanged, half coupling, and effects a remarkably close-coupled connection. In connecting shafts of different diameters the flexible member is usually determined by the size of the smaller shaft, making possible theuse of a smaller and lower-priced coupling.

In addition to all ordinary applications for flexible couplings the Manger Coupling is also easily and advantageously used in many special applications, such as connecting a driving shaft with roll or pinion stand as illustrated in the accompanying diagram.

The photographs here illustrate the compactness and simplicity of the Manger Coupling. For full details of its design and construction, as well as particulars regarding various applications, write for our Bulletin No. 443. A copy will be sent promptly on request, without obligation.

FARREL-BIRMINGHAM COMPANY, INC
366 VULCAN STREET BUFFALO, N. Y.

FARREL SYKES GEARS

The Gear with a Backbone

liquid level in the vessel supplied. Where this is impracticable, the standpipe or chamber may be supplied with compressed air.

Orifice on Discharge Side of Reciprocating Pumps

When lack of pressure head or other conditions prohibit the orifice being placed on the suction side of the pump, the arrangement illustrated in Figure 2 can be used. Here the orifice is located on the discharge side.

The water is directed upward into the chamber, where the pulsations cause the compressed air to contract and expand alternately. The pulsations are thus absorbed in the chamber and allow accurate readings to be obtained with the flow meter. This arrangement is also suitable for use in measuring liquids other than water.

Eliminating Pulsations in Steam, Air and Gas

In measuring a compressible fluid such as steam, air or gas, satisfactory results may be attained by installing sufficient receiver capacity and causing the fluid to undergo one or more abrupt velocity changes. This allows the fluid to compress and expand in the receiver space and consequently damps out the pulsations. If a large receiver is not available, "throttling orifices," Figure 3, may be used to produce changes in velocity. These orifices may be economically constructed of thin sheet metal and inserted between flanges in the line. However, this method results in a pressure loss which is not recoverable, and therefore the use of a receiver may sometimes be preferable. Neither of these methods is available for measuring water or other liquids, since these fluids are practically incompressible.

(The foregoing material was prepared by William Melas, of the Cochrane Corporation, Philadelphia, Pennsylvania.)

speed, speed, speed, speed

is industry's watchword today

CHINALAK

Black Baking Varnish is playing its part in the nation's defense program by enabling motors to run efficiently. Precious "time out" for frequent repairs is reduced to an absolute minimum.

The use of DOLPH'S CHINALAK Black Baking Varnish when rewindings and re-insulating do become necessary assures a long, steady period of trouble-free service.

Its many outstanding qualities include:

1. High resistance to industrial fumes.
2. Flexibility and heat endurance.
3. Oilproofness.
4. High dielectric strength.
5. Waterproofness.

If any one or all of these qualities are necessary in your operations today, let us know the name of the engineer in charge of motor maintenance. Complete information on CHINALAK will be sent him immediately.

JOHN C. DOLPH CO.

Insulating Varnish Specialists

166A Emmett Street Newark, N. J.

PUSH BUTTON STATIONS FOR SURFACE MOUNTING

▲ One of the devices developed in connection with the new line of industrial controls, just announced by Colt's Patent Fire Arms Manufacturing Company, is the No. 202 Colt Push Button Station. It is attractively styled for use with modern

streamlined machines, designed for surface mounting. Cover is of a heavy molded phenolic with a guard ring raised the full height of the start button to prevent accidental operation. Usual mounting is vertical but if horizontal mounting is desired, the buttons can be turned to read correctly in that position. The internal

Rockbestos Wires Permanently Resist
HEAT-MOISTURE-OIL-GREASE-FIRE

These wires are but a few of the 118 different permanently insulated standard constructions developed by Rockbestos to withstand the destructive action of heat and moisture, oil, grease and corrosive fumes without drying out, cracking, rotting, swelling or failing. All of them are absolutely fireproof. File this page under "Wires for Severe Operating Conditions" and refer to it when you reach the wire-specifying stage of your planning. For complete information send for catalog.

Rockbestos Products Corporation, 992 Nicoll Street, New Haven, Connecticut

600 VOLT A.V.C. SWITCHBOARD WIRE — TABLE B
(Underwriters' Type AVB)

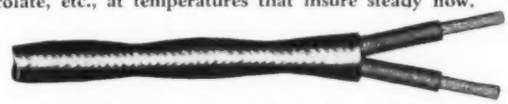
Sizes No. 18 to 4/0 A.W.G. with varnished cambric and felted asbestos insulation and gray, black, white or colored flameproof cotton braid.

Combine fire insurance and fine appearance in your switchboards with Rockbestos Switchboard Wire. It is absolutely fireproof and will not dry out under heat. Sharp, clean bends can be made without cracking as the asbestos wall acts as a cushion under the braid. Rockbestos A.V.C. Hinge Cable and Switchboard Bus Cable have the same fireproof and heatproof characteristics.

INDUSTRIAL HEATING CABLE — TABLE LH

No. 19 A.W.G. nickel-chromium wire insulated with .040" of felted asbestos and covered with 4/64" waterproof lead sheath.

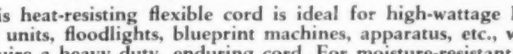
This pliable cable distributes a mild heat evenly over a large area. Prevents freezing of water pipes, wet pipe sprinkler systems, etc. Keeps conveyor pipes for fuel oil, soap, varnish, ink, chocolate, etc., at temperatures that insure steady flow.



ALL-ASBESTOS FLEXIBLE CORD — TABLE CA

Sizes No. 10 to 18 A.W.G. with two or three conductors insulated with felted asbestos, covered with asbestos braid. Also in A.V.C. (asbestos and varnished cambric) constructions.

This heat-resisting flexible cord is ideal for high-wattage lighting units, floodlights, blueprint machines, apparatus, etc., which require a heavy duty, enduring cord. For moisture-resistant construction specify the A.V.C. type. Labeled cord with polarized conductors if desired.



600 VOLT A.V.C. BOILER ROOM WIRE — TABLE C
(Underwriters' Type AVA)

Sizes No. 18 to 4/0 A.W.G. This construction for sizes 18 to 8, sizes 6 to 4/0, have another wall of felted asbestos next to the conductor.

For lighting and control circuits exposed to heat and moisture, oil, grease, corrosive fumes or fire hazard, such as exist around furnaces, ovens, lehrs, soaking pits, boilers, etc., this widely used A.V.C. construction is ideal. Also for locomotive panel wiring and for switchboards requiring an asbestos braided wire.

600 VOLT A.V.C. POWER CABLE — TABLE E
(Underwriters' Type AVA)

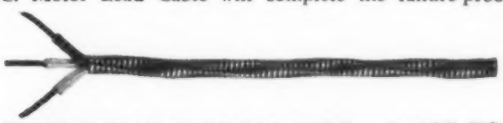
Sizes No. 18 A.W.G. to 1,000,000 CM insulated with laminated felted asbestos and varnished cambric, and asbestos braid. Other constructions for service voltages up to 8000.

This cable is recommended for power circuits and hot spot wiring in or around boiler rooms, ash pits, steam tunnels, soaking pits, tenter frames, glass plants, steel mills, etc. The asbestos and heat-sealed varnished cambric construction has ample moisture resistance and withstands high temperatures indefinitely.

ASBESTOS INSULATED MAGNET WIRE

Round, square and rectangular asbestos insulated conductors finished to meet varying winding conditions and coil treatment requirements.

Protect your motors against heat-induced breakdowns with class B windings of Rockbestos Heat-Resisting Magnet Wire. Leads of A.V.C. Motor Lead Cable will complete the failure-proofing.



THERMOSTAT CONTROL WIRE — TABLE TC

Sizes No. 14, 16 and 18 A.W.G. in two to six conductors with 12½, 25 or 32 mil wall of felted asbestos insulation and cadmium plated steel armor.

A multi-conductor control wire for low voltage intercommunicating, signal and temperature control systems. Its lifetime insulation and rugged steel armor will give you troubleproof circuits.

600 VOLT ALL-ASBESTOS RHEOSTAT CABLE—TABLE R
(Underwriters' Type AI)

Sizes No. 18 A.W.G. to 1,000,000 CM insulated with a heavy wall of felted asbestos, covered with a rugged asbestos braid finished in black, white or colors.

Use this power and rheostat cable for wiring rheostats, switchboards, elevator and locomotive control panels and electrical equipment exposed to heat, fumes and fire hazard. Also for general open wiring in dry, high temperature locations. For solid conductor specify Rockbestos Rheostat Wire, Table A.

600 VOLT A.V.C. MOTOR LEAD CABLE — TABLE L
(Underwriters' Type AVA)

Sizes No. 18 A.W.G. to 1,000,000 CM insulated with two walls of felted asbestos and a high-dielectric, heat-sealed varnished cambric insert, covered with heavy asbestos braid.

Heatproof, fireproof, greaseproof and oilproof, this cable will not dry out and crack, won't burn or carry flame, and will remain permanently flexible. For coil connections, motor and transformer leads where extreme heat and fire hazards are encountered as in steel mills, boiler rooms, etc.

600 VOLT A.V.C. CONTROL CABLE

In one to 19 conductors. Standard stranding A.W.G. No. 12 — 19/No. 25 and No. 9 — 19/No. 22. Other strandings furnished to order.

Designed for use under conditions too severe for control cables with other types of insulation which deteriorate rapidly when exposed to high temperatures. Operates without failure under the attack of heat, oil, grease or corrosive fumes and may be installed in conduit as it has ample moisture resistance.

Also refer to McGraw-Hill Electrical Buyers Reference

ROCKBESTOS — *the wire with permanent insulation*

mechanism is self-contained on a rugged molded block which is mounted directly on the metal base by two screws. Base has two conveniently located mounting holes in opposite corners and has ½ in. and ¾ in. pipe knockouts on both ends.

Standard finish is black top on machine gray bottom, but special color combinations can be supplied.

TEST THERMOCOUPLES IN NEW CHECKING FURNACES

▲ Thermocouples may be checked to greater accuracy and over a wider temperature range in the newly redesigned Leeds and Northrup checking furnace. This equipment is a small electric furnace which provides a zone of practically uniform temperature for the intercomparison of laboratory standard couples and for comparison of laboratory standard and plant standard couples.

A new accessory which increases accuracy of checking is a cylindrical copper equalizing block that fits inside the furnace. Drilled into this block are five wells to hold the comparison standard and the four couples being checked. With the equalizing block, checks can be made within plus or minus 1 degree F. from room temperature up to 1000 degrees F. Without it, checks can be made within plus or minus 3 degrees F. over a range of 300 to 1800 degrees F.

Available with heating elements for either a-c. or d-c. operation on 115 or 230 volts, this furnace requires an input ranging from 40 watts at 300 degrees F. up to 1000 watts at 1800 degrees F. When temperature must be raised rapidly, input can be increased to 5000 watts. Working space inside the furnace is 4 in. in diameter and 36 in. deep. Outside diameter is 14¼ in.

NEW LITERATURE

▲ James H. Matthews and Company has issued several bulletins covering the various products manufactured at the Matthews' plants.

Special Bulletin, No. 146-Z: "A Steel Type Holder Built to Withstand Severest Marking Applications," describes the "Shepherd" holder which is recommended for use in marking ingots, slabs, billets, rails, round and square bars, forgings, products made of stainless and other tough alloy steels.

Catalogue No. 146: "Steel Stamps," describes the safest methods of using steel stamps and the various uses of this type of stamp for industrial marking.

Special Bulletin No. 146-R: "Shell Marking." Matthews marking devices are manufactured for every shell marking requirement, and this bulletin describes the various devices.

Catalogue No. 146-D: In this bulletin a description is given of the proper methods of product identification with Matthews spray and sand blast stencils.

For any of the above catalogues address James H. Matthews & Company, 3942 Forbes Street, Pittsburgh, Pennsylvania.

▲ Whiting Corporation has prepared three new pieces of literature as follows:

1. The Whiting Founder, winter edition, in which they feature a very practical article on cupola operation.

2. Leaflet No. T-103, Junior Hydro-Blast Barrel. This describes the new small size unit developed especially for use in medium and small brass foundries.

3. Leaflet No. 406, New Bottom Door Hoists for cupolas. This illustrates and describes a new and much improved design of a mechanical hoist for raising cupola bottom doors.

Copies may be obtained by writing to the Whiting Corporation, Harvey, Illinois.

▲ Dravo Corporation has prepared a bulletin describing an extremely powerful safety clamp developed by Dravo for use on movable structures, such as cranes, ore bridges and the like, subject to heavy stress and strain in severe wind. Typical installations are described together with a diagram showing the principal operations of the new clamp.

Copies of Bulletin No. 215 may be had by writing to the Dravo Corporation, Neville Island Branch, Pittsburgh, Pennsylvania.

▲ Trumbull Electric Manufacturing Company has available for distribution a booklet describing a new line of combination magnetic starters. These starters are available in sizes No. 1, No. 2, and No. 3. The combinations, including a motor circuit switch disconnect and magnetic starter in one cabinet, are revolutionary in design. The combination units are especially adaptable for use on motor driven machines. Circular No. 330 may be obtained by writing to the Trumbull Electric Manufacturing Company at Plainville, Connecticut.

Also available for interested persons is Circular No. 332, fully describing the Trumbull line of solderless lugs and connectors. There are three intermediate sizes available for convenience wherever a more limited range of wire sizes is desired. This booklet may also be obtained by writing to the address above.

▲ Homestead Valve and Manufacturing Company, Inc., has issued a folder entitled: "Physically Fit to Shoulder Their Jobs for National Defense." This bulletin shows how the speed, endurance and economy of Homestead valves have put them in active service aboard battleships and in defense industries. The various types of valves manufactured by this company are also described with typical installation illustrations.

Copies of this booklet may be obtained by writing to the Homestead Valve and Manufacturing Company, Coraopolis, Pennsylvania.

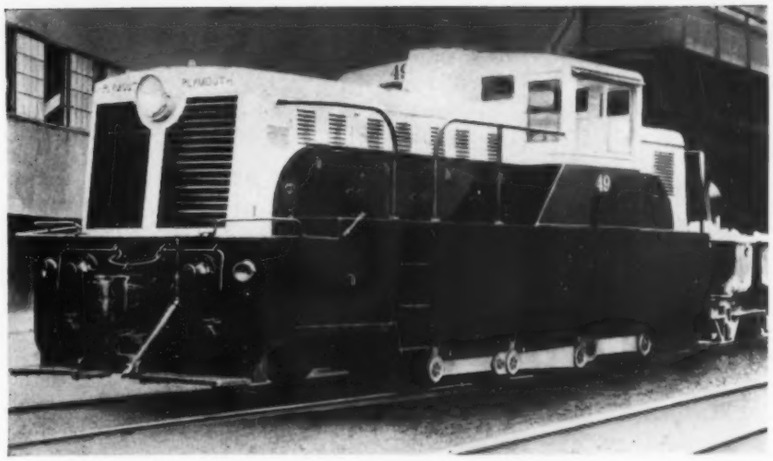
▲ Westinghouse Electric and Manufacturing Company has published a bulletin describing heavy duty metal-clad switchgear for use in steel mills. These units are rated at 600, 1200, 2000, and 3000 amperes for service up to 15,000 volts with interrupting capacities between 1000 and 500,000 kva. General information and distinctive features common to all units are discussed. Both indoor and outdoor types are completely described, attention being given to housing, control devices, elevating mechanism and oil circuit breakers.

A copy of Descriptive Data 32-160 may be secured from department 7-N-20, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania.

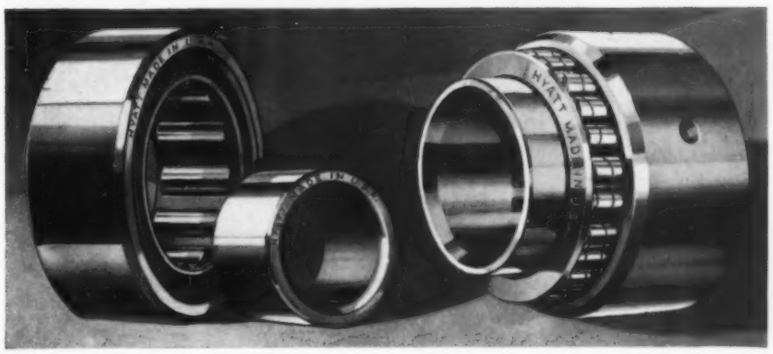
▲ De Laval Steam Turbine Company has available copies of a reprint entitled: "Adjusting Centrifugal Pump Speed Cuts Operating Costs." This article prepared by the chief engineer of the pump and compressor department shows how cost of operating waterworks and boiler-feed pumps driven by constant-speed motors can be reduced by adjusting speed with hydraulic couplings.

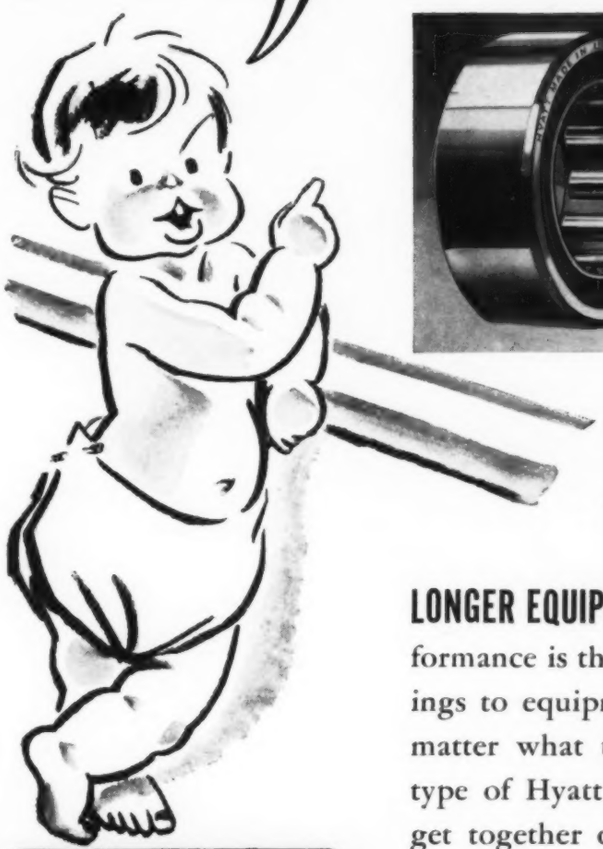
This reprint can be secured from the De Laval Steam Turbine Company at Trenton, New Jersey.

THEY BUILD HYATTS IN TO KEEP WEAR OUT



PLYMOUTH LOCOMOTIVES...built by Plymouth Locomotive Works, Division of the Fate-Root-Heath Company, Plymouth, Ohio ... are equipped with Hyatt Roller Bearings.





KEEP THEM YOUNG WITH HYATTS

LONGER EQUIPMENT LIFE, and carefree bearing performance is the contribution of Hyatt Roller Bearings to equipment into which they are built. No matter what the application, there is a size and type of Hyatt Roller Bearing for the job. Let us get together on design for your new equipment or change-overs. Tell us when and where. Hyatt Bearings Division, General Motors Sales Corporation, Harrison, New Jersey, Chicago, Pittsburgh, Detroit and San Francisco.

HYATT

ROLLER BEARINGS

QUIET

A FLEET OF TRADE AUTOMATIC MARK LIFT TRUCKS

"Giving Excellent Service"

HANDLING TINPLATE AND STEEL COILS FOR FOLLANSBEE STEEL CORPORATION

FORGING ADDS STRENGTH

FOLLANSBEE STEEL CORPORATION

MANUFACTURERS

Follansbee Forge

ELECTRICAL STEEL SHEETS

FOLLANSBEE, W. VA.

March 31, 1941

MILLS: FOLLANSBEE, WEST VIRGINIA; TORONTO, OHIO

GENERAL OFFICES: PITTSBURGH, PENNSYLVANIA

ALL AGREEMENTS ARE SUBJECT TO STRIKES, ACCIDENTS OR OTHER CONTINGENCIES BEYOND OUR CONTROL

Automatic Transportation Company
501 Liberty Avenue
Pittsburgh, Pennsylvania

Attention: Mr. L.W. Crissman

Dear Sir:

At the request of our Mr. Manion, I am writing this letter giving an account of our experience with the Automatic Tractors used for handling tinplate and coils in our Follansbee Plant.

We have in our plant five (5) Automatic lift trucks which have given excellent service. The first unit (type T-LAF) was purchased in 1929; followed by orders in 1933 for a type T.A.T.F. 3000# capacity model; in 1933 a model T.G.T.F. 6000# unit; in 1937 by a gasoline powered unit, Model T.M.T.F.; and in 1940 by a type T.H.R. unit.

Of the above units, four are fork tilting trucks and are used in our warehouse to facilitate the handling of tinplate. The fifth unit purchase in 1940 is for handling coils at our Cold Reducing Mills.

That these units have given satisfactory service is shown by the repeat orders.

At the present time, we are contemplating the purchase of another unit which will be an "Automatic" unit.

Yours truly,

FOLLANSBEE STEEL CORPORATION

W L Darr

Chief Engineer.

WLB:MBM

Here again is a customer's typical expression of the "excellent service" "AUTOMATICS" are giving every industry.

Note how this letter states . . . "That these units have *given satisfactory service* is shown by *repeat orders.*" The first "AUTOMATIC" purchased by Follansbee plant in 1929 was the determining factor for repeat orders for "AUTOMATICS" in 1933; again in 1937; again in 1940 and *now again* in 1941.

The continual acceptance of "AUTOMATICS" by this plant is only *one* example of hundreds of others because "AUTOMATIC" always furnishes proven equipment to give top performance and lowest-cost materials transportation and storage regardless of the problem.

Perhaps you, too, are about to consider a new or expanded materials handling program. Let the experience of this company be your guide to satisfactory performance.

Write, phone or wire—an "AUTOMATIC" representative will call to discuss your material handling program.

AUTOMATIC TRANSPORTATION CO.
DIV. OF THE YALE & TOWNE MFG. CO.
47 W. 87th ST. CHICAGO, ILL.

☆

The Latest Type "AUTOMATIC" Heavy-duty Coil Tractor in Service at Follansbee Plant

FULLY EQUIPPED WITH LATEST "AUTOMATIC" IMPROVEMENTS

For safe controlled speeds; with "AUTOMATIC" Speed-O-Matic full contactor control system—Controlled compression steering with "AUTOMATIC" patented "Power Steer" having indicator type directional control handle—Powered by new type "AUTOMATIC" Super-duty motors for maximum overall capacity with heaviest loads—Improved frame construction with heavy deep sectional members all unit welded and riveted at stress points—Compact chassis design for easy maneuvering in congested areas under full load. Equipped with latest type Industrial battery for heavy-duty operation.

☆

TRADE **AUTOMATIC** MARK **MANUFACTURERS FOR OVER THIRTY YEARS**
Electric Propelled **INDUSTRIAL TRUCKS**

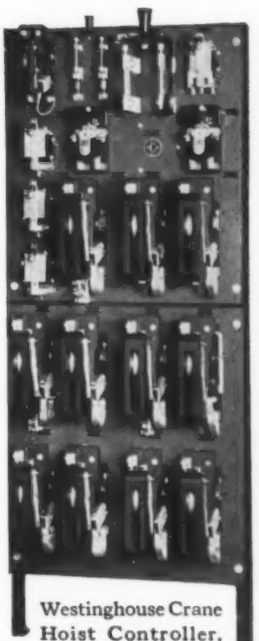
DOWN SAFELY. LOADED!

High-speed light-hook lowering speeds up crane operation

Westinghouse D-C crane control speeds up operation by giving *faster* light-hook lowering speed . . . *without* excessive speeds when lowering heavy loads . . . *without* complications and hazards of load relays.

Westinghouse crane control gives smoother braking action by means of graduated dynamic braking which accomplishes the greater part of deceleration before the magnetic brake sets. This reduces wear on brake lining and wheel and imposes less stress on the crane.

Inching control is made more precise—load handling is made easier, quicker, more accurate. Write today for bulletin DD-9600 containing full details. Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., Dept. 7-N.



Westinghouse Crane Hoist Controller, Class 9635, with new 200 SM contactors.

J-21150

Westinghouse D. C. CRANE CONTROLLERS

W WESTINGHOUSE ELECTRIC

ITEMS OF INTEREST

J. R. Bottoms has been appointed to the position of engineer in the roll and mill department of the Mesta Machine Company, Pittsburgh, Pennsylvania. Mr. Bottoms was recently connected with the Richard Thomas and Company, Ltd., Ebbw Vale, England, in connection with that company's hot and cold strip mills, where he was manager of hot and finishing mill operations. Before that appointment he was superintendent of the Jones and Laughlin Steel Corporation's cold strip mill department. He started with the American Rolling Mill Company at Ashland, Kentucky, in 1923. In 1930, he became superintendent of processing at the Butler strip mill for Armco. He subsequently worked for Republic Steel Corporation, and later at Wheeling Steel Corporation as assistant superintendent of the cold strip mill department. He held the latter position until October, 1936, when he joined Jones and Laughlin Steel Corporation. Mr. Bottoms is a member of the Association of Iron and Steel Engineers.

J. R. BOTTOMS

D. G. Holt, formerly superintendent of maintenance, Tennessee Coal, Iron and Railroad Company, Fairfield, Alabama, has been appointed works manager for E. W. Bliss Company, Salem, Ohio.

Nelson E. Cook, of the Wheeling Steel Corporation, and Chairman of the governing board of the Galvanizers Committee, has announced that the preliminary arrangements for the next spring meeting of the committee, which is to be held in the William Penn Hotel, Pittsburgh, on May 1 and 2, have been completed. This is the ninth meeting of the Galvanizers Committee, which is sponsored by the American Zinc Institute.

The program, as at present, includes a full day of plant inspections, including a visit to the Vandergrift Works of the Carnegie-Illinois Steel Corporation. Dinner and informal discussions will be held on the evening of May 1, at the William Penn Hotel. The sessions on the second day, both morning and afternoon, will be open only to members of the committee. Round table discussions of special topics relating to current problems in galvanizing will follow at both sessions.

The governing board of the committee includes, in addition to Mr. Cook, the following: **R. H. Dibble,** Carnegie-Illinois Steel Corporation, **C. K. Lytle,** Tennessee Coal, Iron and Railroad Company, **W. R. Shimer,** Bethlehem Steel Company, **J. J. Shuman,** Jones and Laughlin Steel Corporation, **C. H. Steele,** Steel Company of Canada, Ltd., and **F. G. White,** Granite City Steel Company.

James G. West, Jr., has been appointed to the Office of Production Management in Washington, D. C. Mr. West will visit closed furnaces throughout the country to determine if they can be rehabilitated to increase production of pig iron. He formerly was in charge of the Chicago district's blast furnaces and coke ovens of the Youngstown Sheet and Tube Company, and has had a wide experience in the blast furnace and coke oven industry throughout the steel industry. Mr. West is a member of the Association of Iron and Steel Engineers and has served on the board of directors.

J. G. WEST, JR.

Howard E. Emigh has been appointed superintendent of the new aluminum alloy rolling mill at Lister, Alabama, of the Reynolds Metal Company, Inc. Mr. Emigh for a number of years was connected with the Ford Motor Company as a consultant and plant supervisor. Prior to that time he was engaged in engineering work for the Wheeling Steel Corporation and the Weirton Steel Company. Recently he was employed as consultant on rolling mill operations for the United Engineering and Foundry Company, Pittsburgh, and also served as general consultant for the Office of Production Management. Mr. Emigh recently became a member of the Association of Iron and Steel Engineers.

Arthur R. Borden has been placed in charge of Hagan Corporation, Hall Laboratories, and Buromin Company activities, with respect to automatic combustion control and boiler water conditioning applications, at the new branch office of those companies in Detroit, Michigan. Mr. Borden will maintain headquarters at 2512 Book Building. **Robert Graf** will handle the activities of Calgon, Inc., at the same address. Mr. Borden and Mr. Graf will be assisted by **W. H. Weitzel.**

Lee H. Hill has been made assistant manager of the Allis-Chalmers Manufacturing Company's electrical department, at Milwaukee, Wisconsin. Mr. Hill has been head of the company's transformer department since 1936, and will now assume, among other duties, general supervision of the electrical department's sales promotional activities. Mr. Hill served two years as instructor in electrical engineering at Cornell University, and then became associated with the transformer department of Westinghouse Electric and Manufacturing Company as design engineer and as engineer-in-charge of power transformer development. For a number of years he was manager of the transformer division of the American Brown Boveri Company, and joined the Allis-Chalmers company in 1931, when it absorbed Brown Boveri.

William Donald has been named assistant to the vice-president in charge of finance for the Carnegie-Illinois Steel Corporation, Pittsburgh, Pennsylvania. Mr. Donald, a native of Scotland, has been associated with subsidiaries of the United States Steel Corporation since April 1, 1905, when he joined the Carnegie Steel Company as a clerk and bookkeeper.

Charles V. Allen, for the past seven years advertising and sales manager for the John C. Dolph Company, Newark, New Jersey, has resigned to join the sales staff of Robert McKeown Company of Newark. He has been succeeded by **James A. Moran,** formerly with the advertising agency of Campbell-Ewald Company.

N. M. Mintz and Associates, Fortieth Street and Calumet Avenue, Chicago, Illinois, have been appointed as sales engineering representatives for Pennsylvania Transformer Company, manufacturers of power and distribution transformers, Pittsburgh, Pennsylvania.

OBITUARY

Arthur L. Freret, 64, chief electrical engineer of the Tennessee Coal, Iron and Railroad Company, died at the Employees Hospital at Fairfield, Alabama, Tuesday, March 25. Mr. Freret had been in failing health for the last six months. He was born in France of American parents, who returned to New Orleans, Louisiana, when their son was a small boy. Mr. Freret was a graduate of Spring Hill College in 1896, and a graduate in electrical engineering from Tulane University in 1900. After graduation he was connected with the city of New Orleans drainage project. He later joined the navy and served in the Spanish-American War.

A. L. FRERET

In 1909, he joined the electrical engineering department of the Tennessee Coal, Iron and Railroad Company and was appointed chief electrical engineer in 1932, which position he held until the time of his death. Mr. Freret was the third man to become chairman of the Birmingham District Section of the Association of Iron and Steel Engineers.

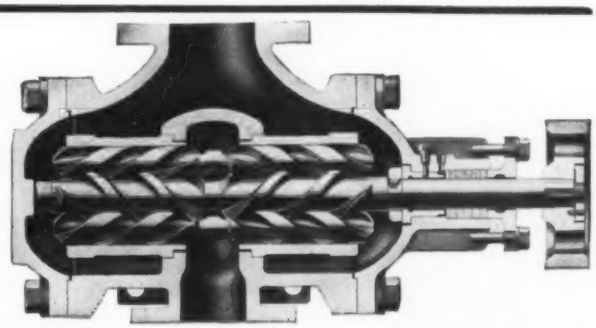
George B. Card, district manager for the H. H. Robertson Company in the Pittsburgh area, died recently. Mr. Card will be succeeded by **M. G. Eighmy,** who will be in charge of the Pittsburgh district sales.

Gambling may be fun...

BUT- should your turbine, engine or oil burner fail through failure of the oil pump, the cost of that failure might be many times the cost of the oil pump; so why gamble on the oil pump?

The DE LAVAL-IMO OIL PUMP

is a guarantee against oil handling troubles. It has no valves, no gears and only one stuffing box and does not depend upon close clearances. It pumps all grades of oil, including light Diesel oil, lubricating oil and heavy Bunker C, against all pressures.



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Founded 1878

EXECUTIVE OFFICE: PASSAIC, NEW JERSEY

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